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ABSTRACT

This module is one of a series of teaching guides that cover diesel mechanics. The module contains six instructional units that cover the following topics: (1) introduction to fuel injection systems and components; (2) injection nozzles; (3) distributor type injection pumps; (4) unit injectors; (5) in-line injection pumps; and (6) pressure timed fuel systems. Each instructional unit follows a standard format that includes some or all of these eight basic components: performance objectives, suggested activities for teachers and students, information sheets, assignment sheets, job sheets, visual aids, tests, and answers to tests and assignment sheets. All of the unit components focus on measurable and observable learning outcomes and are designed for use for more than one lesson or class period. Instructional task analyses; a list of tools, equipment, and materials; and 12 references are also included. (KC)

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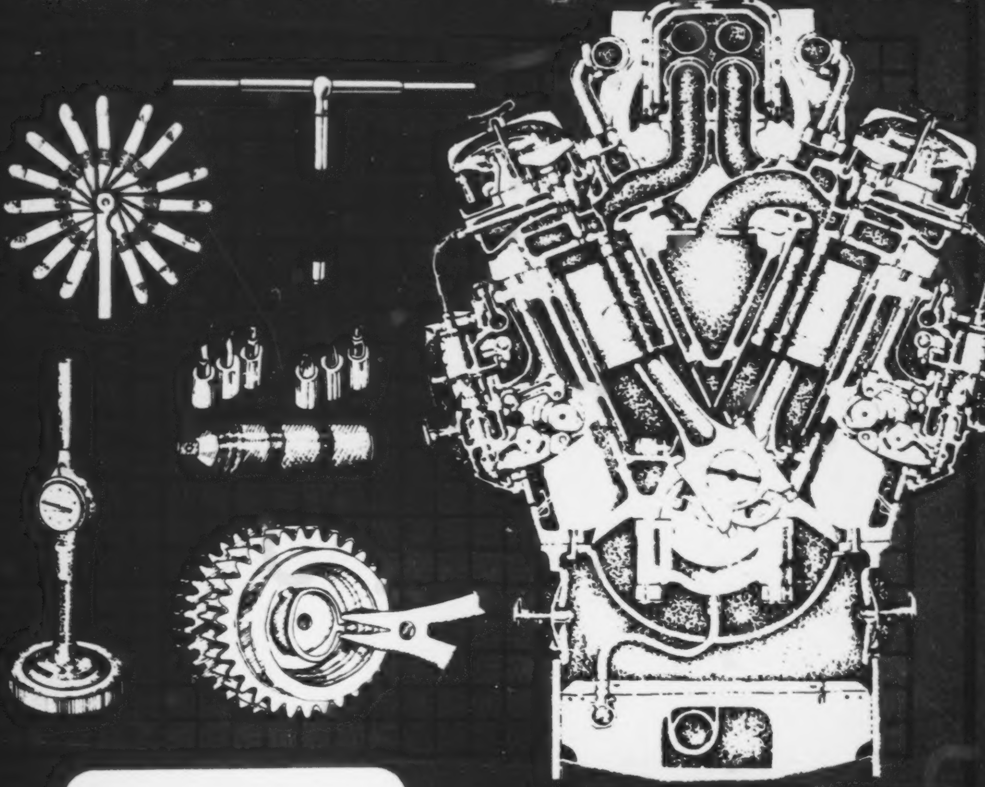

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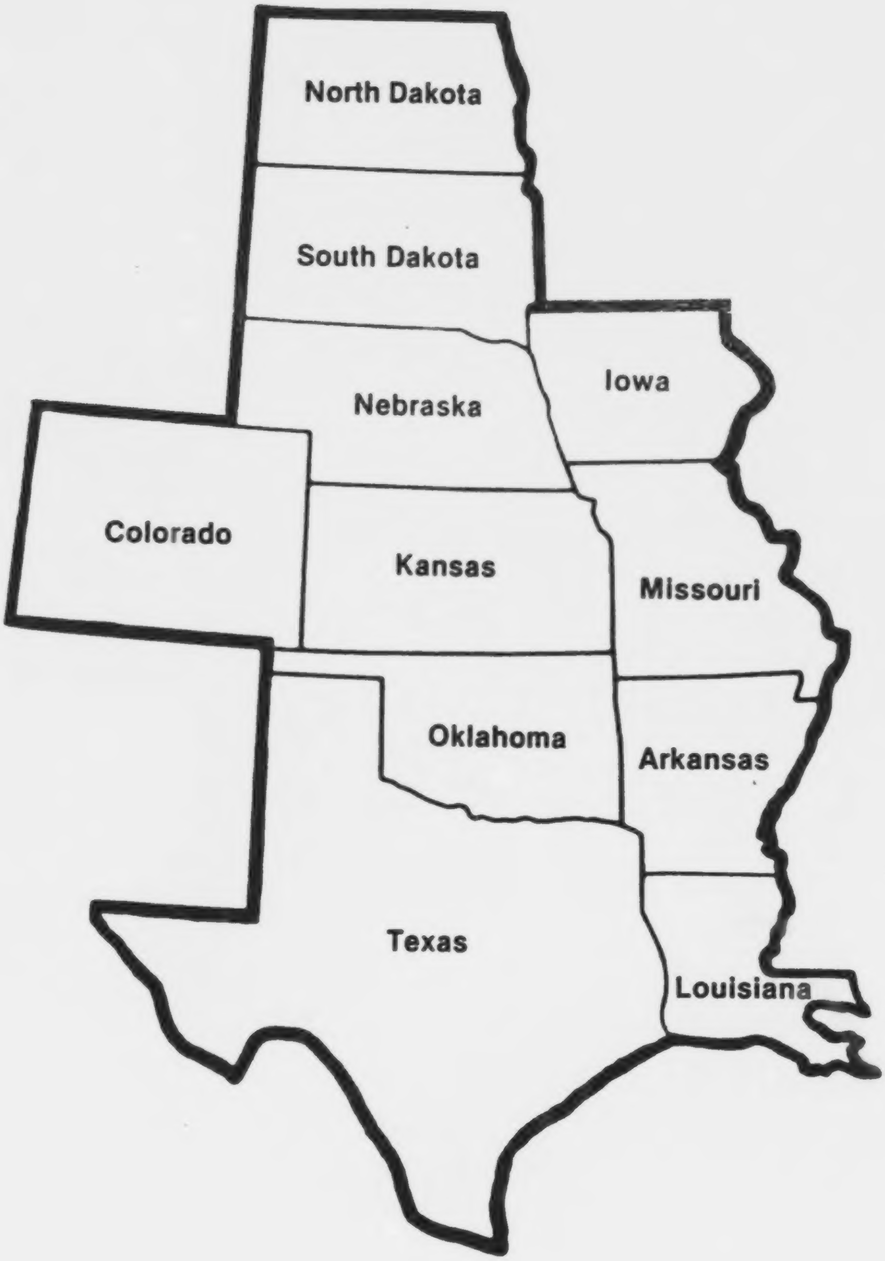
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DIESEL FUEL SYSTEMS

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Developed by

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DIESEL FUEL SYSTEMS

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FOREWORD

Both the development and revision of instructional materials in diesel mechanics have been rewarding efforts because of the talented people who planned and wrote the materials. From the team of teachers and industry representatives has come a series of texts which should offer diesel mechanics students an excellent opportunity for learning required skills.

This publication, *Diesel Fuel Systems*, is designed to be used with the other MAVCC books related to diesel. These include: *Diesel Fundamentals*, *Diesel Electrical Systems*, *Power Trains*, and *Hydraulics*.

As complex as some mechanical activities are, the MAVCC format presents the procedures in logically ordered objectives that facilitate a comfortable learning rate. The format also frees the instructor to concentrate on reinforcing classroom instruction with films, supplemental resources, and other teaching activities that serve to maintain student interest at a high level and to motivate students to learn and do.

Every effort has been made to make this publication basic, readable, and by all means, usable. Three vital parts of instruction have been intentionally omitted from these publications: motivation, personalization, and localization. Those areas are left to the individual instructors and the instructors should capitalize on them. As these publications as used, it is hoped that student's performance will improve and that students will be better able to assume a role in diesel mechanics.

Ron Mehrer, Chairman
Board of Directors
Mid-America Vocational
Curriculum Consortium

Greg Pierce
Executive Director
Mid-America Vocational
Curriculum Consortium

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Appreciation is extended to those individuals who contributed their time and talent to the development of *Diesel Fuel Systems*.

The contents of this publication were planned and reviewed by:

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Special appreciation is extended to those who served on the original advisory committee representing the many MAVCC states, and to the original author, William Foutes, and to the authors of the second edition, Bill Guynes, Marvin Kukuk, and Joe Mathis.

USE OF THIS PUBLICATION

Instructional Units

Diesel Fuel Systems contains six units of instruction. Each instructional unit includes some or all of the basic components of a unit of instruction; performance objectives, suggested activities for teachers and students, information sheets, assignment sheets, job sheets, visual aids, tests, and answers to the tests. Units are planned for more than one lesson or class period of instruction.

Careful study of each instructional unit by the teacher will help to determine:

A. The amount of material that can be covered in each class period
B. The skills which must be demonstrated

  1. Supplies needed
  2. Equipment needed
  3. Amount of practice needed
  4. Amount of class time needed for demonstrations

C. Supplementary materials such as pamphlets or filmstrips that must be ordered
D. Resource people who must be contacted

Objectives

Each unit of instruction is based on performance objectives. These objectives state the goals of the course, thus providing a sense of direction and accomplishment for the student.

Performance objectives are stated in two forms: unit objectives, stating the subject matter to be covered in a unit of instruction; and specific objectives, stating the student performance necessary to reach the unit objective.

Since the objectives of the unit provide direction for the teaching-learning process, it is important for the teacher and students to have a common understanding of the intent of the objectives. A limited number of performance terms have been used in the objectives for this curriculum to assist in promoting the effectiveness of the communication among all individuals using the materials.

Reading of the objectives by the student should be followed by a class discussion to answer any questions concerning performance requirements for each instructional unit.

Teachers should feel free to add objectives which will fit the material to the needs of the students and community. When teachers add objectives, they should remember to supply the needed information, assignment and/or job sheets, and criterion tests.

Suggested Activities for the Instructor

Each unit of instruction has a suggested activities sheet outlining steps to follow in accomplishing specific objectives. Duties of instructors will vary according to the particular unit; however, for best use of the material they should include the following: provide students with objective sheet, information sheet, assignment sheets, and job sheets; preview filmstrips, make transparencies, and arrange for resource materials and people; discuss unit and specific objectives and information sheet; give test. Teachers are encouraged to use any additional instructional activities and teaching methods to aid students in accomplishing the objectives.

Information Sheets

Information sheets provide content essential for meeting the cognitive (knowledge) objectives in the unit. The teacher will find that the information sheets serve as an excellent guide for presenting the background knowledge necessary to develop the skill specified in the unit objective.

Students should read the information sheets before the information is discussed in class. Students may take additional notes on the information sheets.

Transparency Masters

Transparency masters provide information in a special way. The students may see as well as hear the material being presented, thus reinforcing the learning process. Transparencies may present new information or they may reinforce information presented in the information sheets. They are particularly effective when identification is necessary.

Transparencies should be made and placed in the notebook where they will be immediately available for use. Transparencies direct the class's attention to the topic of discussion. They should be left on the screen only when topics shown are under discussion.

Assignment Sheets

Assignment sheets give direction to study and furnish practice for paper and pencil activities to develop the knowledge which is a necessary prerequisite to skill development. These may be given to the student for completion in class or used for homework assignments. Answer sheets are provided which may be used by the student and/or teacher for checking student progress.

Job Sheets

Job sheets are an important segment of each unit. The instructor should be able to demonstrate the skills outlined in the job sheets. Procedures outlined in the job sheets give direction to the skill being taught and allow both student and teacher to check student progress toward the accomplishment of the skill. Job sheets provide a ready outline for students to follow if they have missed a demonstration. Job sheets also furnish potential employers with a picture of the skills being taught and the performances which might reasonably be expected from a person who has had this training.

Test and Evaluation

Paper-pencil and performance tests have been constructed to measure student achievement of each objective listed in the unit of instruction. Individual test items may be pulled out and used as a short test to determine student achievement of a particular objective. This kind of testing may be used as a daily quiz and will help the teacher spot difficulties being encountered by students in their efforts to accomplish the unit objective. Test items for objectives added by the teacher should be constructed and added to the test.

Test Answers

Test answers are provided for each unit. These may be used by the teacher and/or student for checking student achievement of the objectives.

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DIESEL FUEL SYSTEMS

INSTRUCTIONAL TASK ANALYSIS

RELATED INFORMATION: What the Worker Should Know (Cognitive)

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)

UNIT I: INTRODUCTION TO FUEL INJECTION SYSTEMS AND COMPONENTS

1. Terms and definitions
2. Major functions of fuel injection systems and components
3. Common types of fuel injection systems
4. Methods of injecting fuel
5. Major parts of a fuel system
6. Parts of a fuel system
7. Purpose of a fuel transfer pump
8. Types of fuel filters and water separators
9. Stages of fuel filtration
10. Fuel tank maintenance problems
11. Types of fuel lines
12. Replace a fuel filter
13. Check fuel filters using transfer pump pressure

UNIT II: INJECTION NOZZLES

1. Terms and definitions
2. Functions of an injection nozzle
3. Moving parts in an injection nozzle
4. Common types of nozzle valves

RELATED INFORMATION: What the Worker Should Know (Cognitive)	JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)
5. Nozzle characteristics	
6. Operation of an injection nozzle	
7. Adjustment of nozzle opening pressure	
	8. Isolate a faulty injection nozzle
	9. Remove, service, and test an injection nozzle
	10. Install an injection nozzle

UNIT III: DISTRIBUTOR TYPE INJECTION PUMP

1. Terms and definitions	
2. Main parts of a distributor type pump	
3. Rotating parts of a distributor type pump	
4. Functions of main parts	
5. Principles of operation of a distributor type pump	
6. Fuel flow	
7. Charging cycle operation	
8. Discharge cycle operation	
9. Delivery valve operation	
10. Return fuel oil circuit functions	
11. Functions of an end plate	
12. Optional features of a distributor type pump	
	13. Remove a distributor type pump from an engine
	14. Bench test a distributor type pump
	15. Install a distributor type pump on an engine

RELATED INFORMATION: What the Worker Should Know (Cognitive)	JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)

UNIT IV: UNIT INJECTORS

1. Terms and definitions
2. Parts of a unit injector
3. Functions of a unit injector
4. Fuel flow through the unit injector fuel system
5. Sealing parts of a unit injector
6. Differences between no injection and full injection
7. Locate a faulty injector
8. Remove unit injector from engine
9. Disassemble a unit injector
10. Assemble a unit injector
11. Test a unit injector
12. Install a unit injector

UNIT V: IN-LINE INJECTION PUMP

1. Terms and definitions
2. Main parts of an in-line pump
3. Fuel flow from supply tank to delivery
4. Purpose of a hand primer
5. Purpose of a fuel transfer pump
6. Operation of an injection pump
7. Parts and design features of a pumping element
8. Operation of the control rack and sleeve
9. Purpose of a delivery valve

RELATED INFORMATION: What the Worker Should Know (Cognitive)	JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)
10. Plunger and rack positions	
11. Typical tools used for overhauling an in-line injection pump	
	12. Remove an in-line pump
	13. Overhaul an in-line pump
	14. Clean and inspect in-line pump components
	15. Reassemble an in-line pump
	16. Reassemble the RQV governor
	17. Bench test an in-line pump
	18. Time an in-line pump

UNIT VI: PT FUEL SYSTEMS

1. Terms and definitions	
2. Main parts of a PT fuel system	
3. Functions of units of a PT pump assembly	
4. Operation of a PT injection system	
5. Function of pulsation damper	
6. Operation of mechanical governor	
7. Types of PT injectors	
8. Operational steps of PT injectors	
	9. Locate a faulty Cummins injector
	10. Remove and install PT injectors
	11. Adjust an injector plunger and valves using the torque method

RELATED INFORMATION: What the Worker Should Know (Cognitive)

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)

12. Adjust an injector using the dial indicator method
13. Install a PTG fuel pump, and adjust high and low engine idle
14. Test and adjust a PTG fuel pump
15. Time a Cummins injector

DIESEL FUEL SYSTEMS

TOOLS, EQUIPMENT, AND MATERIALS LIST

Adapters

Basic hand tools
Breakover and socket ¾ drive to bar engine

Calibrating nozzles
Calibrating oil
Clean diesel fuel
Clean line plugs
Clean shop towels
Cleaning solvent
Comparator injector tester
Crocus cloth
Cummins engine, NH, NT, NTA, 855, CID series
Cummins timing tool, ST-593

Deep well socket
Distributor type pump
Drain pan
Drive shaft installation tool

Engine with needle valve injector

Feeler gauge
Foot-pounds torque wrench
Fuel oil
Fuel pipe socket

Hand tachometer
Hand tools set
Heel bar
High pressure hand pump

Idle adjusting tool
Inch-pounds torque wrench
Injection lines
Injector nut socket wrench
Injector rocker level actuator
Injector spray tip driver
Injector tube bevel reamer
Injector vise and rack freeness tester

Manufacturer's specifications

Needle valve fuel injector
Nozzle tester

Oil can

Pans
Parts tray
Pipe tee, ⅜"
Portable high pressure PC timer
Pressure gauge
PTG fuel pump
PTR fuel pump
Pump specification sheet
Pump test stand
Pump tools

Remote tachometer

Safety glasses
Service manual
Shipping caps

Test stand adapter
Test stand manual
Timing plug gauge
Tool kit
Torque wrench

Vacuum gauge
Vise

White grease
Workbench

DIESEL FUEL SYSTEMS

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Fundamentals of Service: Engines. 5th ed. Moline, IL: Deere and Company, 1980.

Kates, Edgar J., and William E. Luck. *Diesel and High Compression Gas Engines*. 3rd ed. Chicago: American Technical Society, 1974.

Mack Engine Manual. King of Prussia, PA: Educational Communications, Inc.

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Roosa Master: Operation and Instructional Manual: Model DP Pump. Hartford, CT: Stanadyne/Hartford Division/Roosa Master.

Service Bulletin No. 3379011-01: Injector Plunger and Valve Adjustments. Columbus, IN: Cummins Engine Co., December, 1985.

Service Bulletin No. 3379101-11: PT Fuel Pump Calibration. Columbus, IN: Cummins Engine Co., December 1985.

Service Manual, Detroit Diesel Engines, Series 53. Detroit, MI: Detroit Diesel Allison, 1980.

Schulz, Erich J. *Diesel Mechanics*. 2nd ed. New York: Gregg Division, McGraw-Hill Book Company, 1983.

Toboldt, William K. *Diesel Fundamentals, Service, Repair*. South Holland, IL: Goodheart-Willcox Company, Inc., 1980.

INTRODUCTION TO FUEL INJECTION SYSTEMS AND COMPONENTS
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to change a fuel filter and check a faulty filter. Competencies will be demonstrated by completing the job sheets and unit tests with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to fuel injection systems and components with the correct definitions.
2. Select major functions of fuel injection systems and components.
3. Name the common types of fuel injection systems.
4. Distinguish between methods of injecting fuel.
5. Identify six major parts of a fuel system.
6. Match the parts of a fuel system with their functions.
7. Select true statements concerning the purpose of a fuel transfer pump.
8. Complete statements concerning types of fuel filters and water separators.
9. Match types of filters with the correct stages of fuel filtration.

OBJECTIVE SHEET

10. Select from a list fuel tank maintenance problems.
11. Match fuel lines with the correct purposes.
12. Demonstrate the ability to:
    a. Replace a fuel filter. (Job Sheet #1)
    b. Check fuel filters using transfer pump pressure. (Job Sheet #2)

INTRODUCTION TO FUEL INJECTION SYSTEMS AND COMPONENTS
UNIT I

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in this unit of instruction.

(NOTE: This activity should be completed prior to the teaching of this unit.)

B. Make transparencies from the transparency masters included with this unit.

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information sheet.

F. Discuss information sheet.

(NOTE: Use the transparencies to enhance the information as needed.)

G. Provide students with job sheets.

H. Discuss and demonstrate the procedures outlined in the job sheets.

I. Integrate the following activities throughout the teaching of this unit:

1. Make a display of the different types of fuel injection systems.
2. Demonstrate the spray pattern of various injectors.
3. Emphasize safety procedures to follow when working with fuel injectors.
4. Take a field trip to a fuel injection shop.
5. Show students different high pressure lines.
6. Demonstrate safety precautions on high pressure lines.
7. Have a display of different types of filters.
8. Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas for improvement.

J. Give test.

K. Evaluate test.

L. Reteach if necessary.

REFERENCES USED IN DEVELOPING THIS UNIT

A. Dagel, John F. *Diesel Engine Repair.* New York: John Wiley and Sons, Inc., 1982.

B. Kates, Edgar J. and William E. Luck. *Diesel and High Compression Gas Engines.* 3rd ed. Chicago: American Technical Society, 1974.

C. Schulz, Erich J. *Disel Mechanics.* 2nd ed. New York: Gregg Division, McGraw-Hill Book Company, 1983.

D. Toboldt, William K. *Diesel Fundamentals, Service, Repair.* South Holland, IL: Goodheart-Willcox Company, Inc., 1980.

SUGGESTED SUPPLEMENTAL RESOURCES

A. Films

Diesel Injection Pump Test Stand

1. VTR — U71010
2. VTR — U71011
3. VTR — U72015

Available from:

Deere & Company
Distribution Service Center
1400 Third Avenue
Moline, IL 61625

B. Slides

Diesel Fuel Systems — Fuel Flow #42

These slides should be available from your local Caterpillar dealer.

INTRODUCTION TO FUEL INJECTION SYSTEMS AND COMPONENTS
UNIT I

INFORMATION SHEET

I. **Terms and definitions**

A. Atomize — Break down into small particles

B. Cetane number — The rating of a diesel fuel's ignition

C. Flash point — When fuel is heated to a point where it gives off a flammable vapor

D. Fuel injection nozzle — Atomizes and distributes fuel evenly into the combustion chamber

E. Fuel injection pump — Times, measures, and delivers fuel under pressure to the injection nozzles

F. Fuel lines — High and low pressure tubes that connect the fuel system

G. Governor — A speed-sensing device that employs centrifugal force and spring tension to govern engine speed

H. Ignition — Combustion of fuel mixture in the combustion chamber

I. Ignition delay — Period of time from injection to actual ignition

J. Injection — Method of forcing fuel into a chamber for combustion

K. Micron — A unit of measurement that is used to rate the efficiency of filters; one micron equals one millionth of a meter or 0.000039 inch

L. Primary filter — Filters out initial impurities

M. Secondary filter — The second filter in a fuel system; it has a finer filtering capacity

N. Transfer pump — Moves fuel from the fuel tank to the fuel pump

O. Unit injector — Pump and fuel injection nozzle combined into one unit

P. Water separator — A cup or bowl usually at the bottom of the fuel filter that allows the heavier water to settle to the bottom to be drained off

INFORMATION SHEET

II. **Major functions of fuel injection system**

   A. Supplies the correct quantity of fuel

   B. Times the fuel delivery

   C. Controls the delivery rate

   D. Atomizes the fuel

   E. Distributes fuel evenly throughout the combustion chamber

III. **Types of fuel injection systems**

   A. Unit injector (Detroit)

   B. Inline pump (Mack, Cat, and others)

   C. Pressure timed (PT) (Cummins)

   D. Distributor pump (Farm equipment)

IV. **Methods of injecting fuel**

   A. Nozzles

      1. Pressure operated

      2. The nozzle and pump are separate and connected with a high pressure line.

   B. Injectors

      1. Mechanically operated

      2. Operated from the engine cam through a pushrod and rocker arm

V. **Major parts of fuel system** (Transparency 1)

   A. Fuel tank

   B. Fuel transfer pump

   C. Fuel filter

   D. Fuel injection pump

   E. Unit injector

   F. Fuel injection nozzles

INFORMATION SHEET

VI. **Functions of fuel system parts** (Transparencies 1 and 2)

- A. Fuel tank — Stores fuel
- B. Fuel transfer pump — Supplies fuel to injection pump at low pressure
- C. Fuel filter — Cleans the fuel
- D. Fuel injection pump — Times, measures, and delivers fuel under pressure to injection nozzles
- E. Fuel injection nozzle — Atomizes and distributes fuel evenly into combustion chamber
- F. Unit injector — Performs functions of both the injection pump and nozzle as one unit

VII. **Purposes of fuel transfer pumps** (Transparency 1)

- A. Draw fuel from supply tank through fuel filters
- B. Force fuel under low pressure into injection pump

VIII. **Types of fuel filters and water separators** (Transparencies 3-6)

- A. Element type
  - 1. Water separator (Transparencies 3 and 4)
    - a. Has no resistance to flow
    - b. Separates water by gravity or weight
    - c. Sometimes has a fuel heater (optional)
  - 2. Primary filter
    - a. Has little resistance to flow
    - b. Is on the suction side of the transfer pump
    - c. Sometimes has a water separator with drain at the bottom
  - 3. Secondary filter
    - a. Is on the pressure side of the transfer pump
    - b. Usually is the final filter
    - c. Filters the fine particles in the fuel

    (NOTE: Primary and secondary filters may be connected in series. See Transparency 5.)

INFORMATION SHEET

B. Disposable (Transparency 6)

1. Spin-on filter

   a. Gasket is part of the filter

   b. Easy to change for more serviceability

   c. Has little resistance to fuel flow for primary filter

   d. Fuel flows in the inlet and through the paper filter where it separates the impurities

2. Clip-on filter

   a. Easy to change

   b. Made of clear plastic so you can see when it needs to be replaced

   (NOTE: Some of these can be installed improperly so refer to appropriate service manual when replacing.)

IX. **Stages of fuel filtration** (Transparency 1)

A. First stage — Filter screen at tank or transfer pump

B. Second stage — Primary filter

C. Third stage — Secondary filter

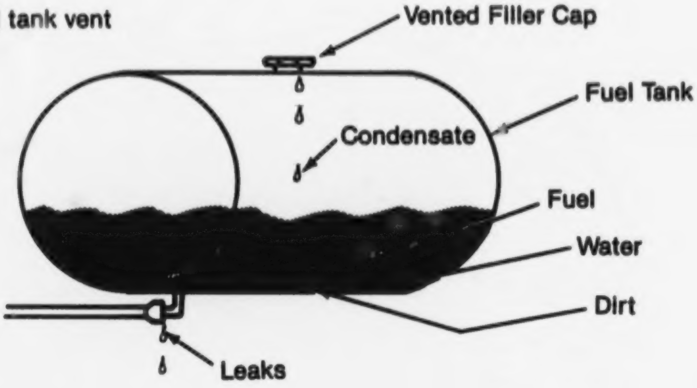
X. **Fuel tank maintenance problems**

A. Leaks

B. Condensation or water

C. Dirt

D. Clogged tank vent



INFORMATION SHEET

XI. **Types of fuel lines and purposes**

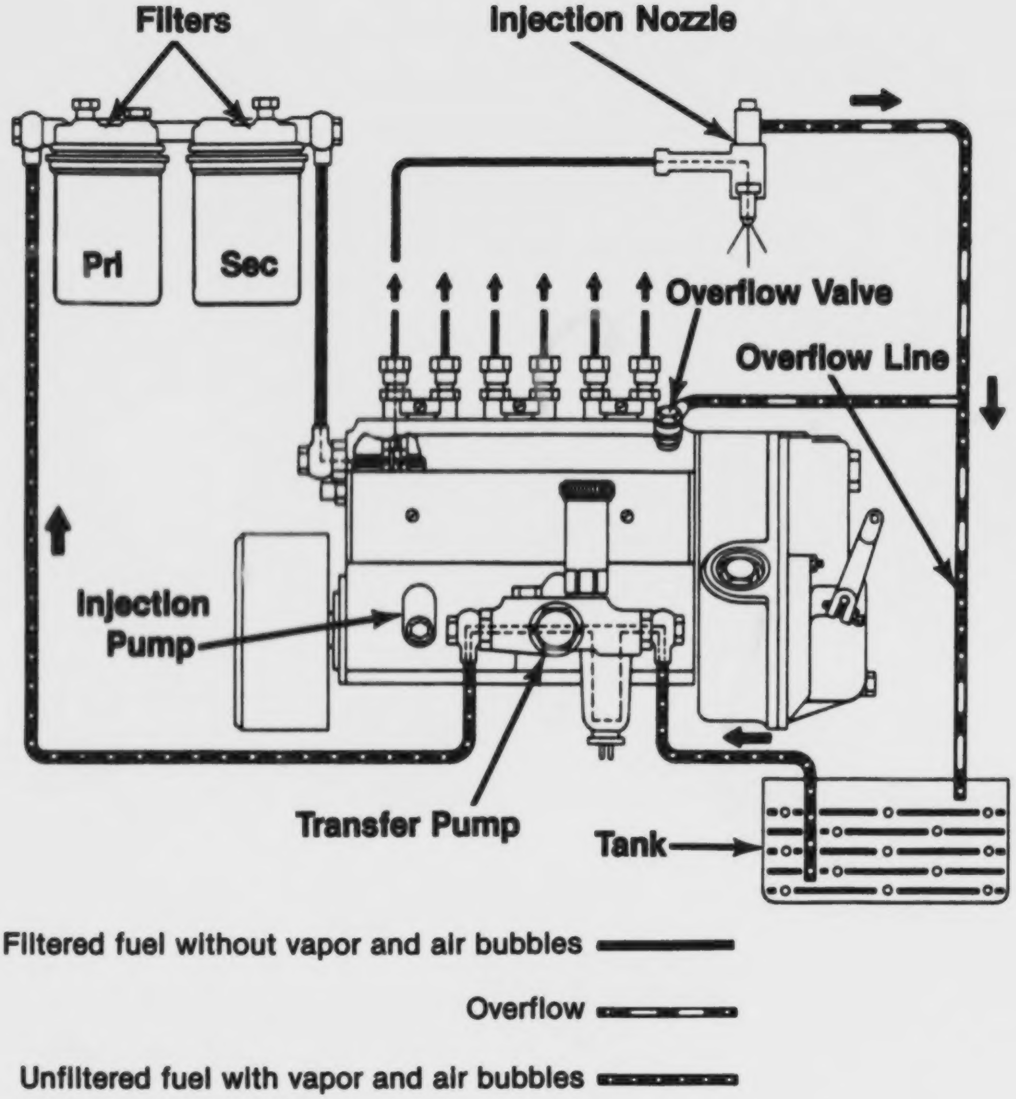
A. Return low pressure lines — Transfer leak-off fuel from injectors to tank or pump inlet

(NOTE: The lines can be made from various materials.)

B. Schedule 80 high pressure lines — Transfer fuel between injection pump and injector

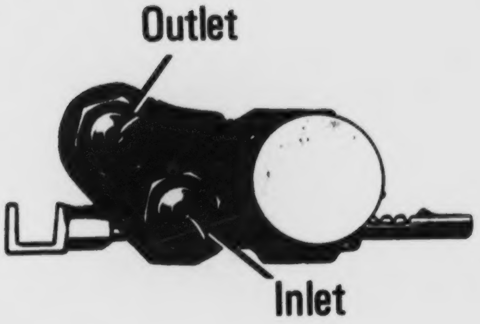
C. Supply low pressure lines — Transfer fuel between tank and injection pump

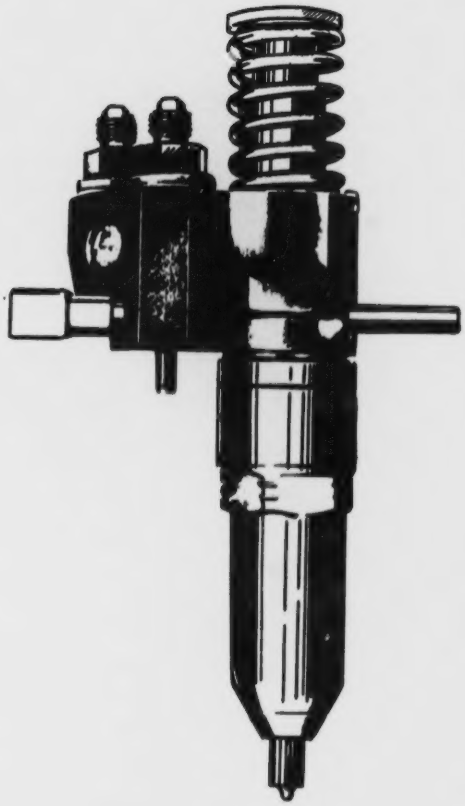
Fuel System Components


Filters
Injection Nozzle
Pri
Sec
Overflow Valve
Overflow Line
Injection Pump
Transfer Pump
Tank
Filtered fuel without vapor and air bubbles
Overflow
Unfiltered fuel with vapor and air bubbles

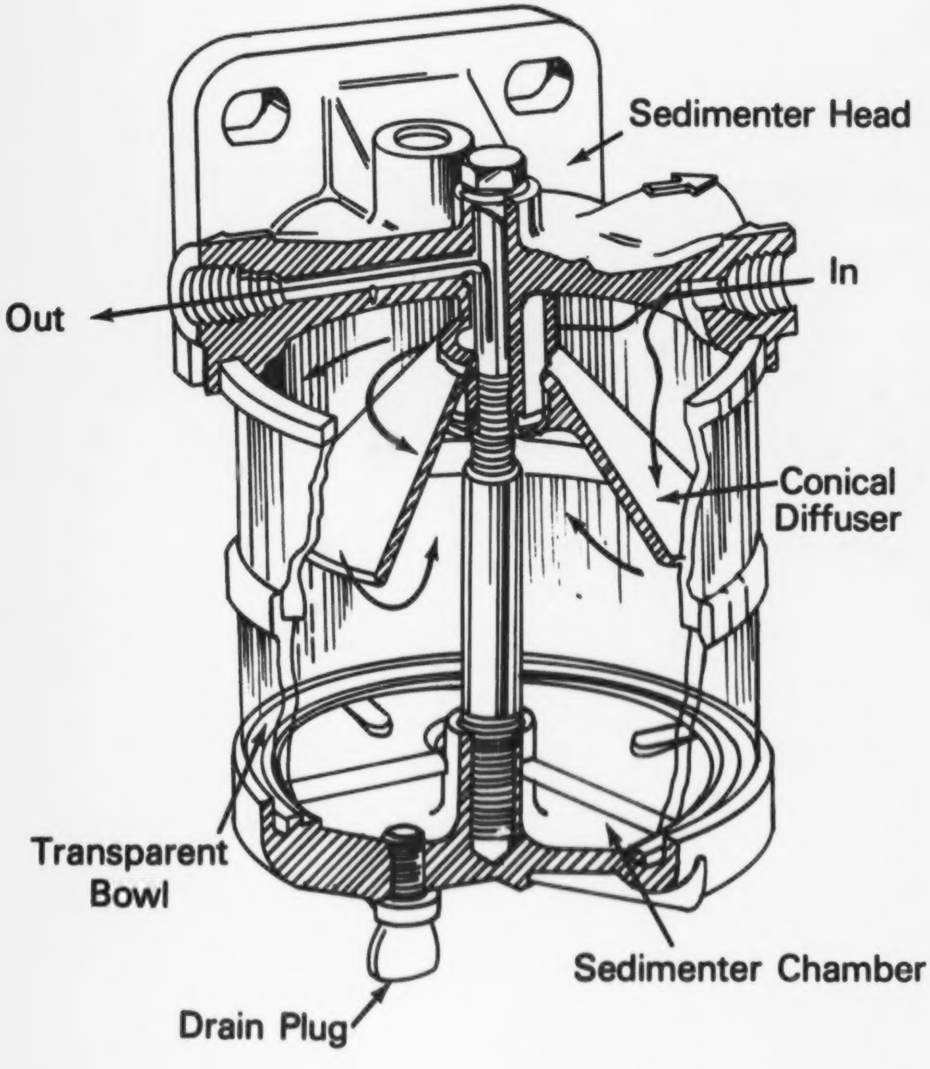
Courtesy of Robert Bosch Corporation

Unit Injector

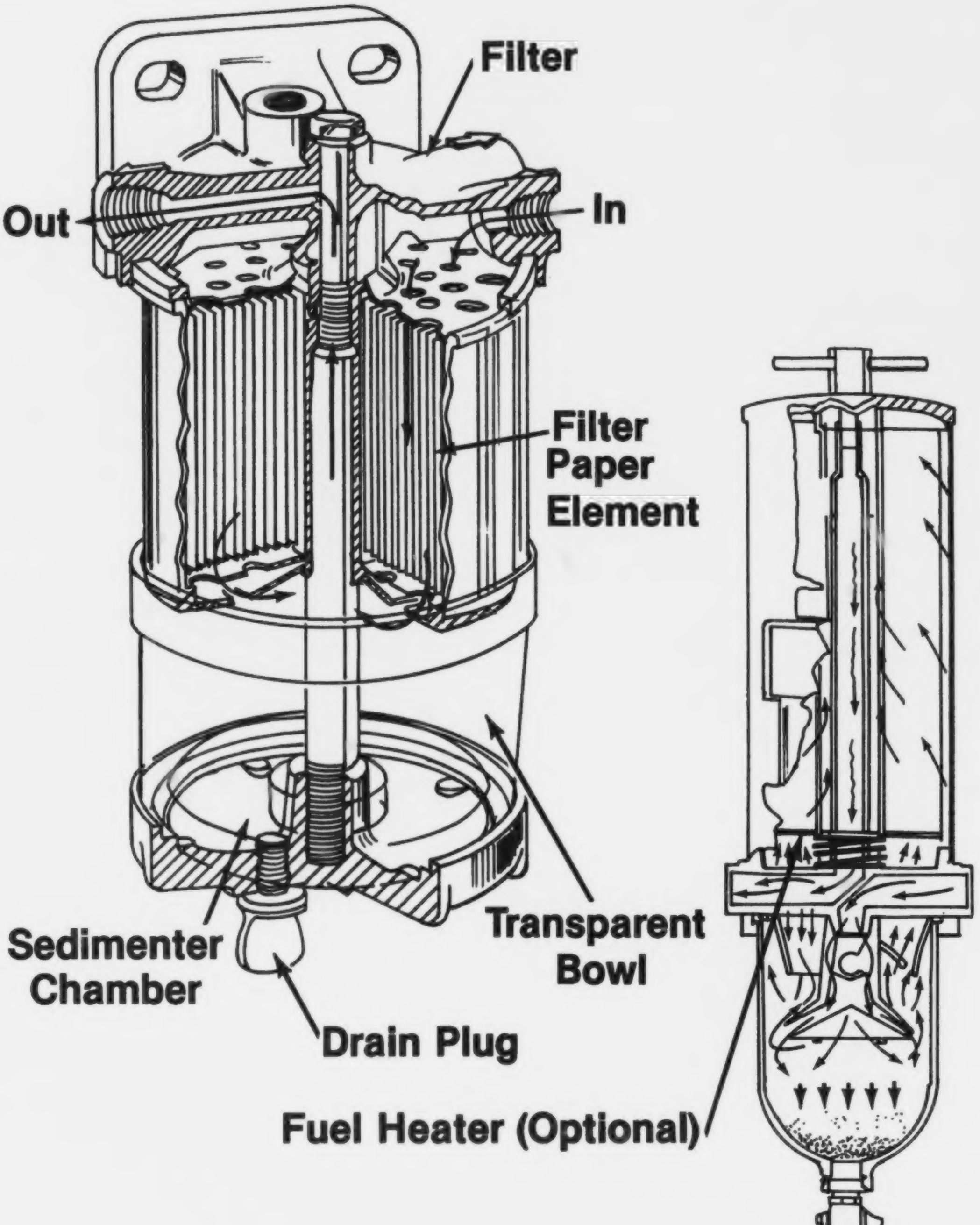

Outlet
Inlet



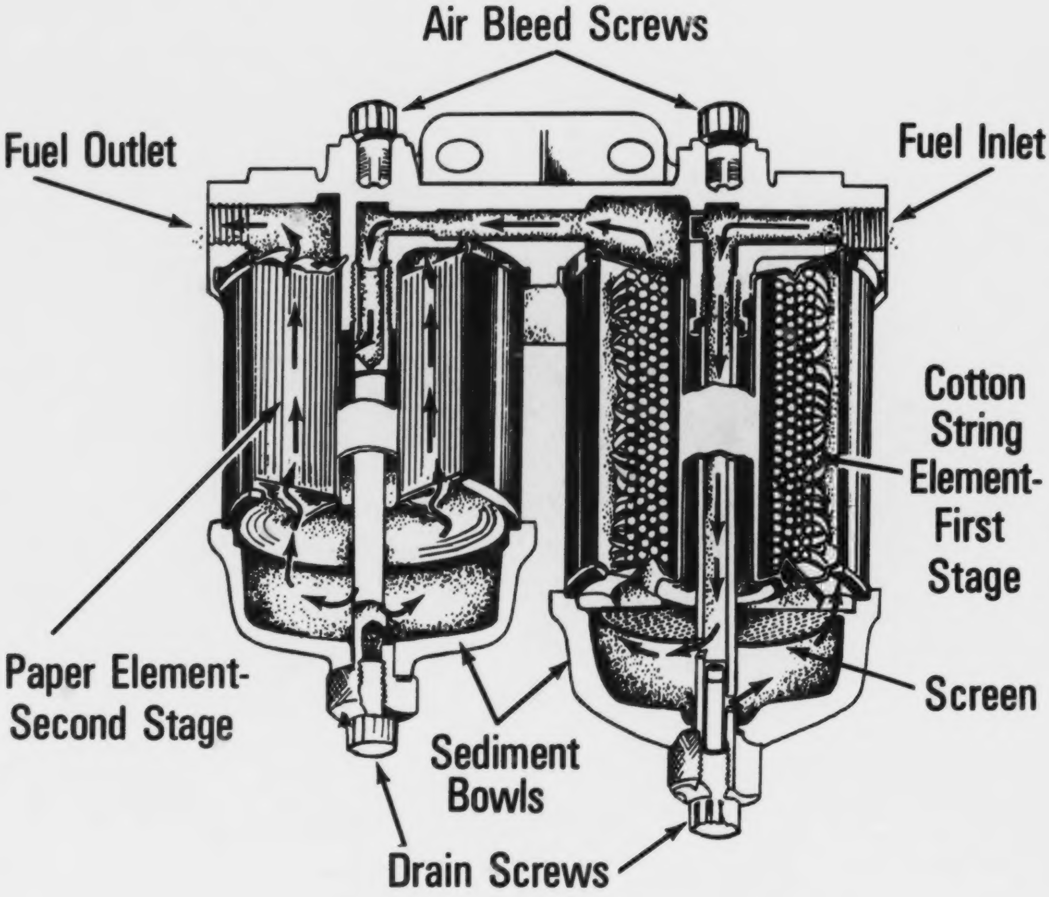
Water Separator


Sedimenter Head
In
Out
Conical Diffuser
Transparent Bowl
Sedimenter Chamber
Drain Plug

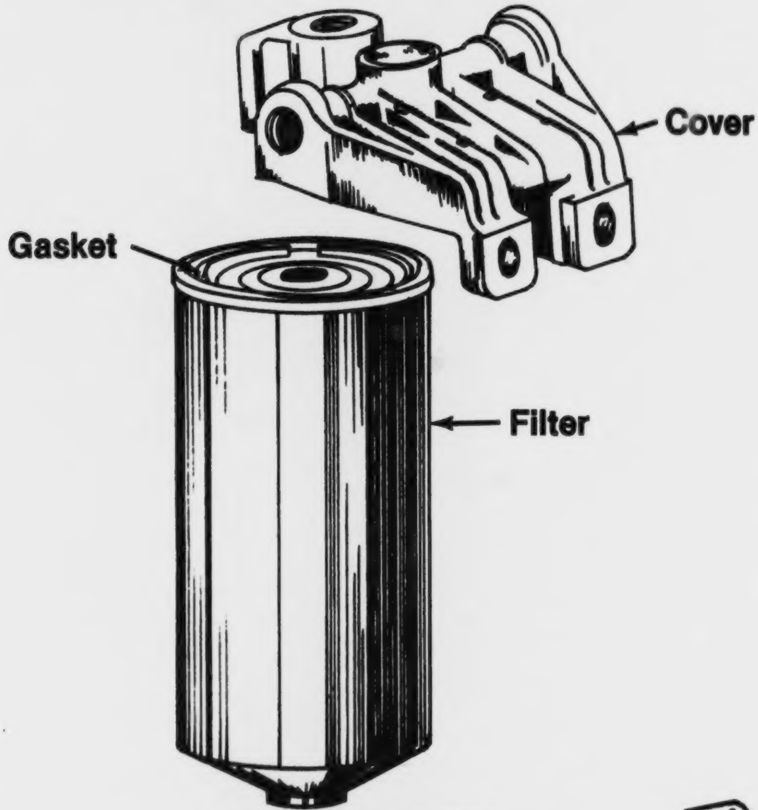
Water Separator and Filter Combination


Filter
Out
In
Filter Paper Element
Sedimenter Chamber
Transparent Bowl
Drain Plug
Fuel Heater (Optional)

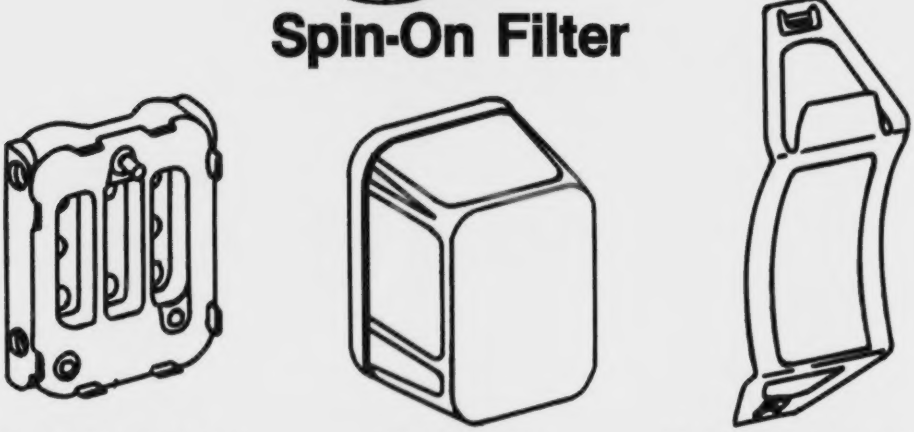
Series Fuel Filters


Air Bleed Screws
Fuel Outlet
Fuel Inlet
Cotton String Element-First Stage
Screen
Paper Element-Second Stage
Sediment Bowls
Drain Screws

Disposable Fuel Filters



Spin-On Filter


Fuel Filter Body

Fuel Filter

Hold Down Spring

Clip-On Filter
(Stanadyne)

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INTRODUCTION TO FUEL INJECTION SYSTEMS AND COMPONENTS
UNIT I

JOB SHEET #1 — REPLACE FUEL FILTER

A. Tools and materials

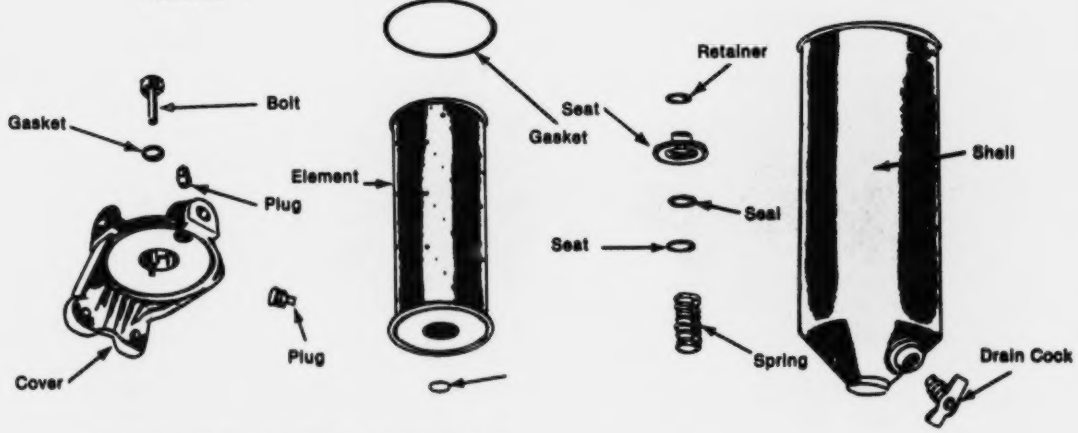
1. Basic hand tools
2. Appropriate service manual
3. Clean shop towels
4. Appropriate drain pan to catch fuel from filters

(NOTE: The wiring harness, starter, or other electrical equipment must be shielded, since fuel oil can damage the electrical insulation.)

B. Procedure

1. With engine stopped, place container under filter and open drain cock. (Figure 1)

FIGURE 1


Retainer
Bolt
Gasket
Seat
Gasket
Shell
Element
Plug
Seal
Seat
Plug
Spring
Drain Cock
Cover

Courtesy of Detroit Diesel Corporation

2. Loosen the cover nut or bolt just enough to allow fuel to drain.
3. Close drain cock.
4. While supporting the shell, unscrew the cover nut or bolt and remove the shell and element.
5. Remove and discard the cover nut retaining ring, if used.

JOB SHEET #1

6. Remove and discard the element and shell gasket.

7. Wash the shell thoroughly with clean fuel oil.

8. Dry shell with compressed air.

9. Examine the element sealing and retaining ring to make sure it has not slipped. (See Figure 1.)

   (NOTE: The sealing ring seat and spring hold the filter against the cover to seal it at the top and bottom. Without this, the fuel will be unfiltered.)

10. Place a new filter over the stud and push it down against the element seat.

11. Make sure the drain cock is closed.

12. Fill the shell two-thirds full with CLEAN fuel.

    (NOTE: If engine is equipped with hand primer, install filter, but do not fill at this time with fuel. After installation pump fuel in the filter shell with primer pump. This will insure clean fuel to the system.)

13. Replace shell gasket in its recess.

    (CAUTION: Make sure old gasket has been removed from cover.)

14. Replace gasket on the cover nut or bolt.

15. Place the shell and element in position under the cover.

16. Then thread the cover bolt in the center stud.

17. Tighten the cover bolt just enough to prevent fuel leakage.

18. Remove the pipe plug at the top of the cover and complete filling the shell with fuel.

    (NOTE: For Detroit engines a Kent Moore primer [J5956] may be used to prime the entire fuel system. This will eliminate trash in the system from dirty fuel or container.)

19. Start the engine and check the fuel system for leaks.

INTRODUCTION TO FUEL INJECTION SYSTEMS AND COMPONENTS
UNIT I

JOB SHEET #2 — CHECK FUEL FILTERS USING TRANSFER PUMP PRESSURE

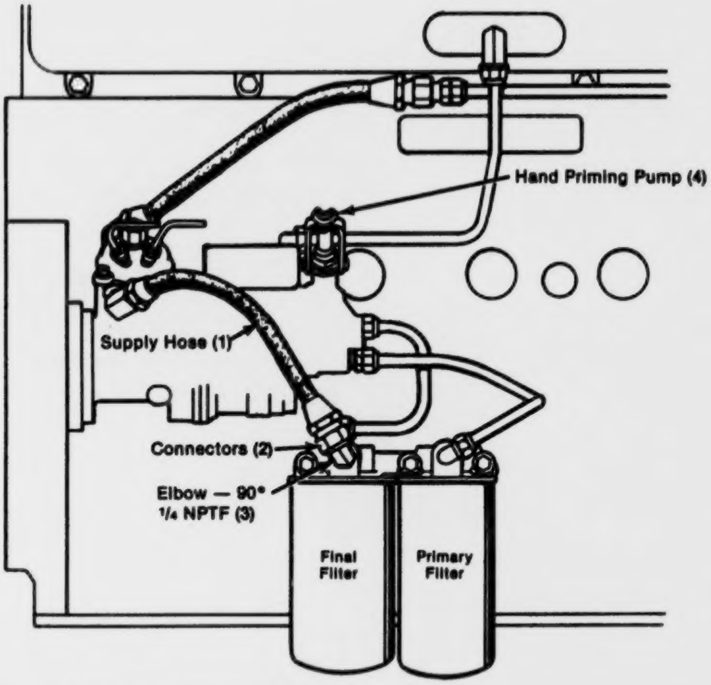
A. Tools and materials

1. Basic hand tool set
2. Appropriate service manual
3. Clean shop towels
4. 3/8" pipe tee
5. Pressure gauge or Beyers model 100 pressure test kit (combination pressure and vacuum)
6. Vacuum gauge or Beyers model 100

B. Procedure

1. Disconnect the supply by loosening the connector (2) at elbow (3) (Figure 1).

FIGURE 1

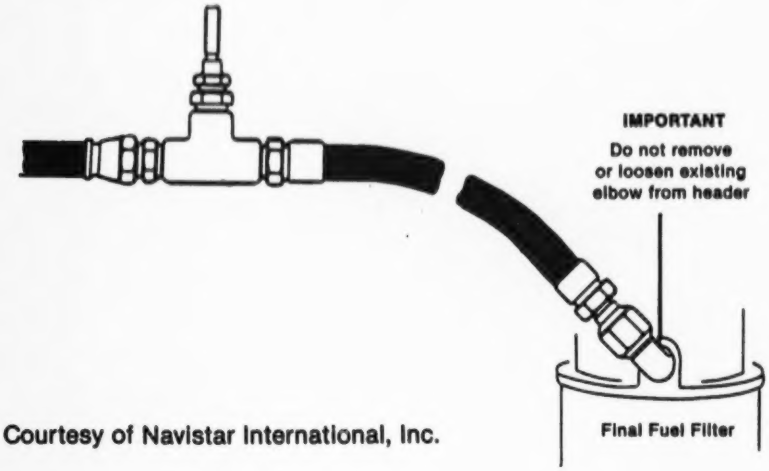

Hand Priming Pump (4)
Supply Hose (1)
Connectors (2)
Elbow — 90°
1/4 NPTF (3)
Final Filter
Primary Filter

Courtesy of Navistar International, Inc.

JOB SHEET #2

2. Install tee fitting as shown in Figure 2.

FIGURE 2


IMPORTANT
Do not remove
or loosen existing
elbow from header
Final Fuel Filter

Courtesy of Navistar International, Inc.

3. Connect pressure gauge or Beyers Model 100 pressure test kit (SE-2239) at tee shown in Figure 2.

4. Run engine at specified RPM ____________ and take two pressure readings: ____________ ____________.

5. If specification ____________ is not reached, change fuel filters.

   (NOTE: If changing fuel filters does not bring fuel pressure into specs, a vacuum check on the suction side should be taken. If fuel filters correct the reading, DO NOT check inlet restriction.)

INTRODUCTION TO FUEL INJECTION SYSTEMS AND COMPONENTS
UNIT I

PRACTICAL TEST
JOB SHEET #1 — REPLACE FUEL FILTER

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ____________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Drained filter.	______	______
3. Used care not to get fuel on electrical parts.	______	______
4. Removed gasket from housing.	______	______
5. Checked seat and seat spring.	______	______
6. Primed with clean fuel and clean container or used primer pump on those engines so equipped.	______	______
7. Checked in/put away tools and materials.	______	______
8. Cleaned the work area.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #1 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:				
No spills	4	3	2	1
No leaks	4	3	2	1
Removed old gasket	4	3	2	1

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

INTRODUCTION TO FUEL INJECTION SYSTEMS AND COMPONENTS
UNIT I

PRACTICAL TEST
JOB SHEET #2 — CHECK FUEL FILTERS USING TRANSFER PUMP PRESSURE

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ______________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Used service manual.	______	______
3. Used correct tools.	______	______
4. Looked up specs before testing pressure.	______	______
5. Connected test equipment properly.	______	______
6. Ran engine at proper RPM.	______	______
7. Replaced filters if needed.	______	______
8. Checked in/put away tools and materials.	______	______
9. Cleaned the work area.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #2 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:				
Had right specs	4	3	2	1
Ran engine at proper rpm	4	3	2	1
Determined filter condition	4	3	2	1

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

INTRODUCTION TO FUEL INJECTION SYSTEMS AND COMPONENTS
UNIT I

NAME ______________________________ SCORE ________________________

TEST

1. Match the terms on the right with their correct definitions.

______a. Break down into small particles

______b. The rating of a diesel fuel's ignition

______c. High and low pressure tubes that connect the fuel system

______d. Times, measures, and delivers fuel under pressure to the injection nozzles

______e. When fuel is heated to a point where it gives off a flammable vapor

______f. Atomizes and distributes fuel evenly into the combustion chamber

______g. Moves fuel from fuel tank to fuel pump

______h. Combustion of fuel mixture in the combustion chamber

______i. Period of time from injection to actual ignition

______j. Method of forcing fuel into a chamber for combustion

______k. A cup or bowl usually at the bottom of the fuel filter that allows the heavier water to settle to the bottom to be drained off

______l. The second filter in a fuel system; it has a finer filtering capacity

______m. Pump and fuel injection nozzle combined into one unit

______n. Filters out initial impurities

1. Atomize
2. Cetane number
3. Flash point
4. Fuel injection nozzle
5. Fuel injection pump
6. Fuel lines
7. Governor
8. Ignition
9. Ignition delay
10. Injection
11. Micron
12. Primary filter
13. Secondary filter
14. Transfer pump
15. Unit injector
16. Water separator

TEST

_____o. A unit of measurement that is used to rate the efficiency of filters; one of these units equals one millionth of a meter or 0.000039 inch

_____p. A speed-sensing device that employs centrifugal force and spring tension to govern the engine speed

2. Select major functions of a fuel injection system by placing an "X" in the appropriate blanks.

_____a. Supplies the correct quantity of fuel

_____b. Pulls the fuel from the pump

_____c. Returns fuel to the filters

_____d. Atomizes the fuel

_____e. Distributes fuel evenly throughout the combustion chamber

3. Name three common types of fuel injection systems.

a. ____

b. ____

c. ____

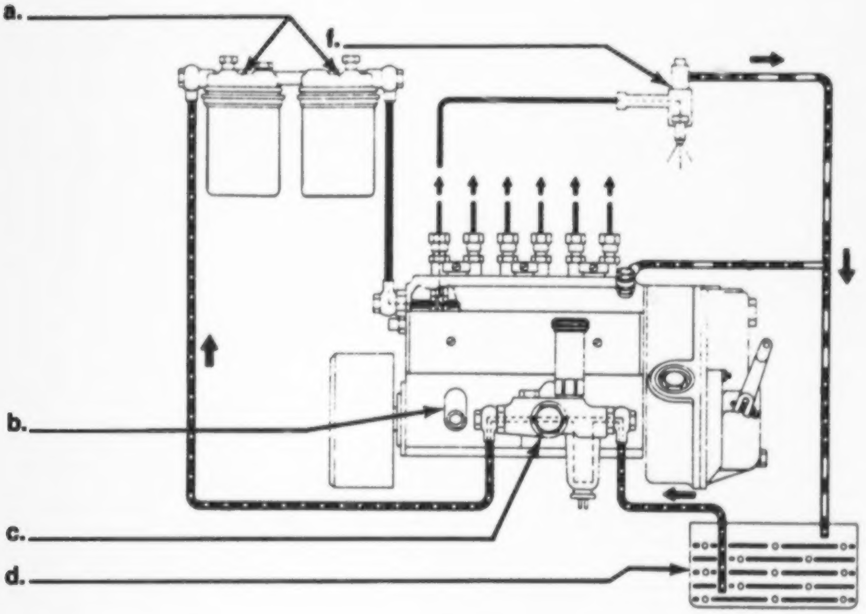
4. Distinguish between the two methods of injecting fuel by placing an "N" next to the characteristics of nozzles and an "I" next to the characteristic of injectors.

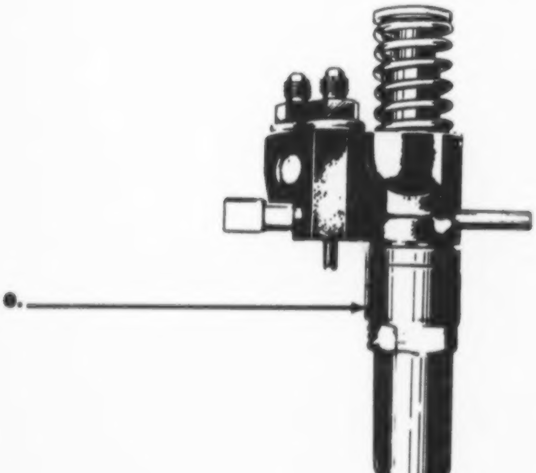
_____a. Pressure operated

_____b. Mechanically operated

TEST

5. Identify the six major parts of a fuel system as shown in the following illustration. Place your answers in the blanks provided.





TEST

6. Match the parts of a fuel system on the right with their functions.

_____a. Stores fuel

_____b. Cleans the fuel

_____c. Supplies fuel to injection pump at low pressure

_____d. Times, measures, and delivers fuel under pressure to injection nozzles

_____e. Atomizes and distributes fuel evenly into combustion chamber

_____f. Performs functions of both the injection pump and nozzle as one unit

1. Fuel filter
2. Fuel injection nozzle
3. Fuel injection pump
4. Fuel tank
5. Fuel transfer pump
6. Unit injector

7. Select true statements concerning the purposes of fuel transfer pumps by placing an "X" beside the true statement(s).

_____a. Draw fuel from supply tank through fuel filters.

_____b. Force fuel under high pressure through injection pump.

8. Complete statements concerning the types of fuel filters and water separators by circling the correct words.

a. A (**primary, secondary**) filter is located on the suction side of the transfer pump.

b. The (**primary, secondary**) filter is usually the final filter.

c. Disposable filters are (**easy, difficult**) to change.

d. A water separator separates water by (**gravity, pumps**).

9. Match types of filters on the right with the correct stages of fuel filtration on a typical diesel fuel system.

_____a. First stage

_____b. Second stage

_____c. Third stage

1. Secondary filter
2. Primary filter
3. Filter screen

TEST

10. Select from the following list the fuel tank maintenance problems.

______a. Gasoline

______b. Leaks

______c. Dirt

______d. Clogged tank vent

______e. Condensation

______f. Water separator

11. Match types of fuel lines on the right with their purposes.

______a.	Transfer leak-off fuel from injectors to tank or pump	1.	Supply low pressure lines
______b.	Transfer fuel between injection pump and injector	2.	Return low pressure lines
______c.	Transfer fuel between tank and injection pump	3.	Schedule 80 high pressure lines

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

12. Demonstrate the ability to:

a. Change a fuel filter. (Job Sheet #1)

b. Check fuel filters using transfer pump pressure. (Job Sheet #2)

INTRODUCTION TO FUEL INJECTION SYSTEMS AND COMPONENTS
UNIT I

ANSWERS TO TEST

1. a. 1
   b. 2
   c. 6
   d. 5
   e. 3
   f. 4
   g. 14
   h. 8
   i. 9
   j. 10
   k. 16
   l. 13
   m. 15
   n. 12
   o. 11
   p. 7

2. a, d, e

3. Any three of the following:
   a. Unit injector
   b. Pressure timed (PT)
   c. Inline pump
   d. Distributor pump

4. a. N
   b. I

5. a. Fuel filter
   b. Injection pump
   c. Transfer pump
   d. Tank
   e. Unit injector
   f. Injection nozzle

6. a. 4
   b. 1
   c. 5
   d. 3
   e. 2
   f. 6

7. a

8. a. Primary
   b. Secondary
   c. Easy
   d. Gravity

9. a. 3
   b. 2
   c. 1

ANSWERS TO TEST

10. b, c, d, e

11. a. 2
    b. 3
    c. 1

12. Performance skills evaluated to the satisfaction of the instructor

INJECTION NOZZLES
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to demonstrate the ability to remove, service, and test an injection nozzle. Competencies will be demonstrated by completing the job sheets and the unit tests with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to injection nozzles with the correct definitions.
2. List two functions of an injection nozzle.
3. Identify four moving parts in an injection nozzle.
4. Identify three common types of nozzle valves.
5. Match the types of nozzles with their characteristics.
6. Select true statements concerning the operation of an injection nozzle.
7. Explain how the nozzle opening pressure is adjusted.
8. Demonstrate the ability to:
    a. Isolate a faulty injection nozzle. (Job Sheet #1)
    b. Remove, service, and test an injection nozzle. (Job Sheet #2)
    c. Install an injection nozzle. (Job Sheet #3)

INJECTION NOZZLES
UNIT II

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in this unit of instruction.

(NOTE: This activity should be completed prior to the teaching of this unit.)

B. Make transparencies from the transparency masters included with this unit.

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information sheet.

F. Discuss information sheet.

(NOTE: Use the transparencies to enhance the information as needed.)

G. Provide students with job sheets.

H. Discuss and demonstrate the procedures outlined in the job sheets.

I. Integrate the following activities throughout the teaching of this unit:

1. Demonstrate lapping and cleaning nozzles.
2. Show students different styles and mountings of injections.
3. Demonstrate proper cleaning of area before removing injector.
4. Discuss capsule type fuel nozzles used on Caterpillar engine.
5. Show films or slides dealing with injection nozzles.
6. Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas for improvement.

J. Give test.

K. Evaluate test.

L. Reteach if necessary.

REFERENCES USED IN DEVELOPING THIS UNIT

A. Dagel, John F. *Diesel Engine Repair.* 1st ed. New York, NY: John Wiley and Sons, Inc., 1982.

B. Schulz, Erich J. *Diesel Mechanics.* 2nd ed. Dallas, TX: Gregg Division/McGraw-Hill Book Company, 1983.

SUGGESTED SUPPLEMENTAL RESOURCES

Text

6.9L Diesel Reference Manual. Ford Motor Co., 1982.

(NOTE: Contact your local Ford dealer for this text.)

Slides

Analyzing Fuel Nozzle and Fuel Line Failures, from Caterpillar.

(NOTE: Contact your local Caterpillar dealer for these slides.)

INJECTION NOZZLES
UNIT II

INFORMATION SHEET

I. **Terms and definitions**

  A. Injection nozzle — Nozzle, nozzle holder, valve, and spring assembly

  B. Nozzle assembly — Valve, body, and spray valve

  C. Orifice — Small hole

  D. Pintle — Valve in which the end extends into a shank or pin

II. **Functions of injection nozzle**

  A. Atomizes the fuel for better combustion

  B. Spreads the fuel spray to fully mix with air

III. **Moving parts in an injection nozzle** (Transparency 1)

  A. Valve

  B. Spring

  C. Spindle

  D. Retainer

IV. **Common types of nozzle valves** (Transparencies 2 and 3)

  A. Single hole, capsule

  B. Multiple orifice

  C. Single hole, pintle

V. **Nozzle characteristics** (Transparencies 2 and 3)

  A. Hole type — Used for engines with precombustion chambers

  B. Pintle type (inward-opening) — Produces a hollow spray; used for engines with precombustion chambers

  C. Pintle type (outward opening) — Does not dribble fuel; used for engines with precombustion chambers

  D. Multiple orifice — Has several small holes; holes have a tendency to clog

  (NOTE: New style is a pencil type.)

INFORMATION SHEET

VI. **Operation of an injection nozzle**

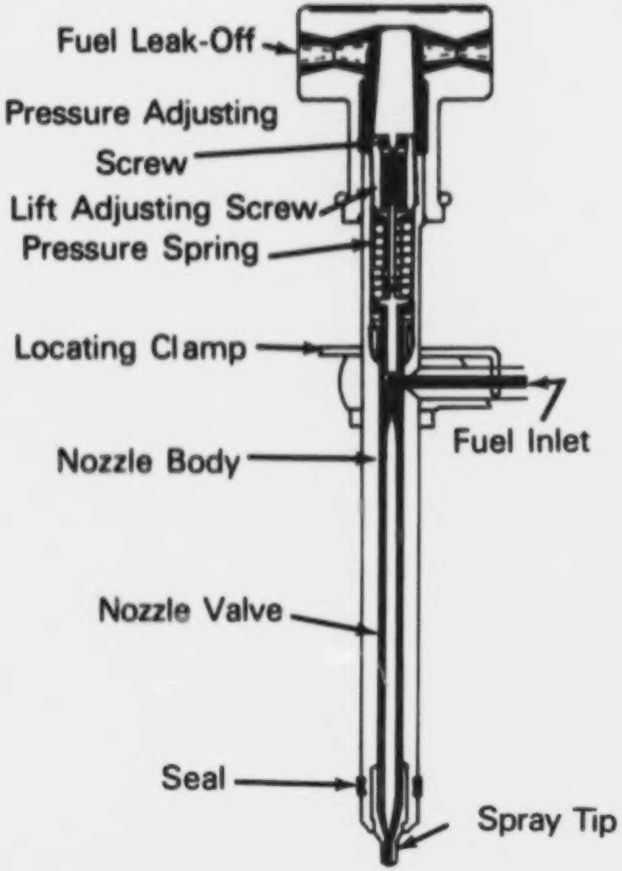
A. Hydraulically or pressure operated by fuel delivered from the injection pump

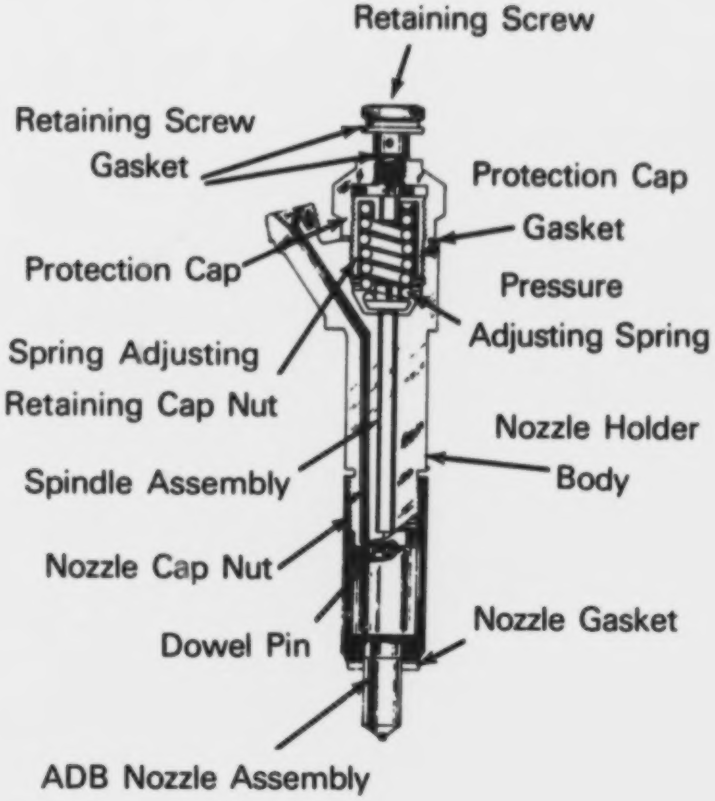
B. Spring loaded valve is lifted allowing pressurized fuel to spray out through one or more orifices into combustion chamber

(NOTE: Some injection nozzles have adjustable valve lifts. Refer to manufacturer's service manual.)

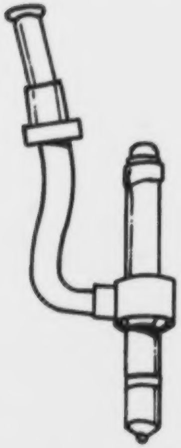
VII. **Adjustment of nozzle opening pressure** — Adjusted by a screw or shims on the valve spring. (Transparency 1)

Moving Parts in Nozzle

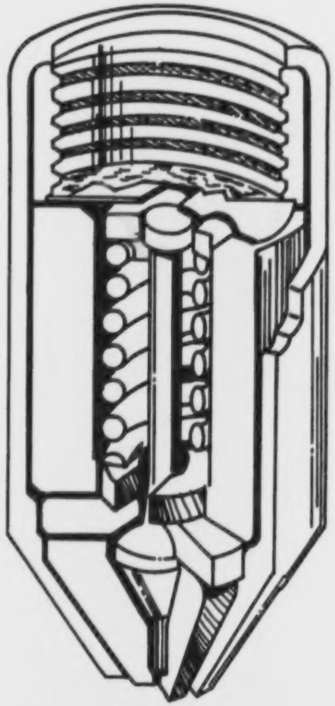

Fuel Leak-Off
Pressure Adjusting Screw
Lift Adjusting Screw
Pressure Spring
Locating Clamp
Fuel Inlet
Nozzle Body
Nozzle Valve
Seal
Spray Tip


Retaining Screw
Retaining Screw Gasket
Protection Cap
Gasket
Protection Cap
Pressure Adjusting Spring
Spring Adjusting Retaining Cap Nut
Nozzle Holder Body
Spindle Assembly
Nozzle Cap Nut
Dowel Pin
Nozzle Gasket
ADB Nozzle Assembly

Nozzle Valve Assembly



Roosa Master pencil nozzle
as used on GM engines



Caterpillar Inward Opening Nozzle
(Capsule type)

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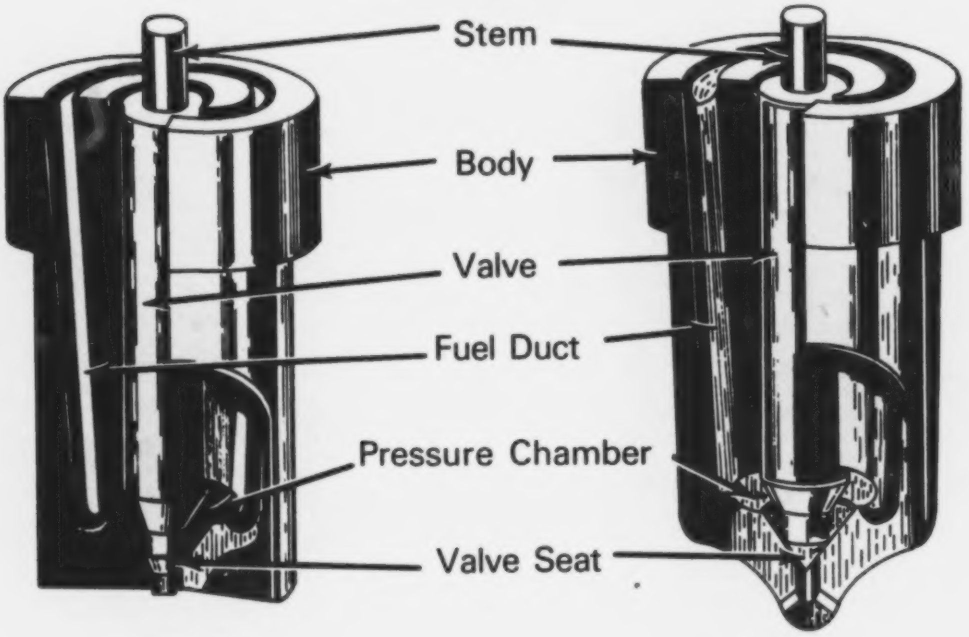
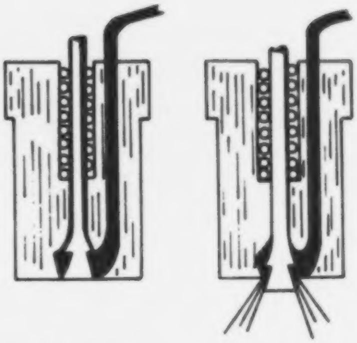
Nozzle Valve Assembly

(Continued)


Stem
Body
Valve
Fuel Duct
Pressure Chamber
Valve Seat

Pintle

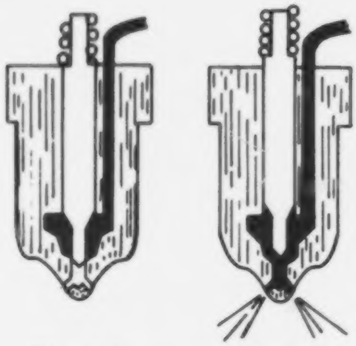
Orifice



Closed Open

Outward-Opening

Pintle-Type



Closed Open

Inward-Opening

Hole-Type

INJECTION NOZZLES
UNIT II

JOB SHEET #1 — ISOLATE A FAULTY INJECTION NOZZLE

A. Tools and materials

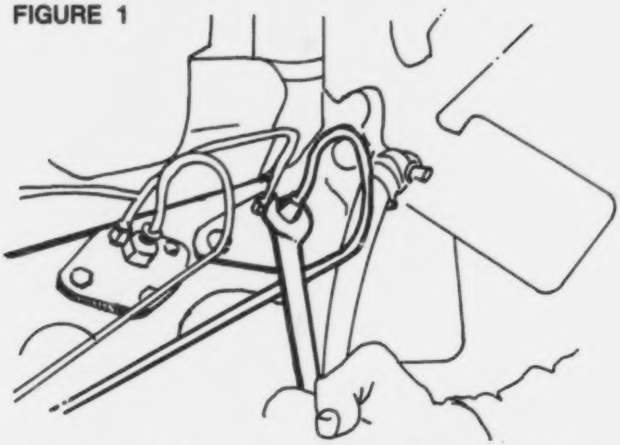
1. Basic hand tools
2. Appropriate service manual
3. Remote tachometer
4. Clean diesel fuel
5. Clean shop towels
6. Safety glasses

B. Procedure

(CAUTION: Follow all shop safety procedures.)

1. Disconnect tach drive cable.
2. Connect remote tachometer.
3. Start the engine.
4. Loosen injector line on #1 cylinder. (Figure 1)

FIGURE 1



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(NOTE: Fuel flow should be evident.)

JOB SHEET #1

5. Listen for a change in engine speed, and watch tachometer for an rpm drop.

   (NOTE: An injector that is operating correctly will cause an rpm drop in engine; refer to manufacturer's specifications for the correct amount.)

6. Repeat for each cylinder.

7. Remove and repair any faulty nozzles.

   (NOTE: This will not work at idle speed on engine equipped with later model Stanadyne pumps. Idle speed should be set at 1000 rpm.)

INJECTION NOZZLES
UNIT II

JOB SHEET #2 — REMOVE, SERVICE, AND TEST AN INJECTION NOZZLE

A. Tools and materials

1. Nozzle tester
2. Appropriate service tool kit
3. Appropriate service manual
4. Safety glasses

B. Procedure

(NOTE: The job sheet detailed here is general; for specific installations and models, follow the specifications and procedures according to the engine manufacturer's instruction manual.)

(CAUTION: Follow all shop safety procedures.)

1. Remove nozzle.
   a. Clean the area around the nozzle.
   b. Remove and cap the injection and leak-off lines.
   c. Remove the nozzle from the engine. Number nozzles to cylinder to trace problem.

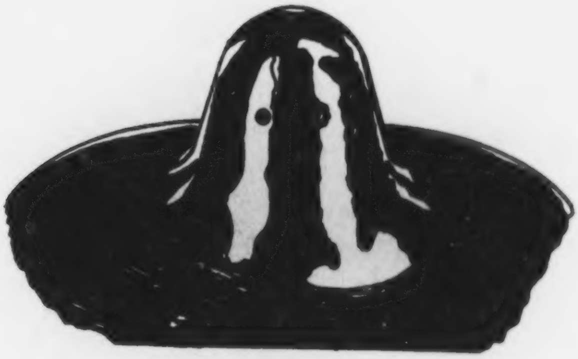
      (NOTE: Some nozzles may require special tools or procedures for removal. See manufacturer's service manual.)
2. Clean nozzle.
   a. Soak entire nozzle assembly in clean solvent or calibration fluid after discarding outer seals.

JOB SHEET #2

b. Clean and decarbon spray tip and nozzle body with a brass wire brush. (Figure 1)

(NOTE: Never use emery cloth or steel wire brush because the precision tip will be damaged.)

FIGURE 1



3. Test nozzle.

(NOTE: All nozzles require careful handling and a special tool kit to perform any service. When working on several nozzles, DO NOT mix nozzle parts.)

a. Place nozzle into nozzle holder.

b. Tighten nozzle nut, first by hand, then with correct size wrench.

c. Torque nozzle according to the values given by the engine manufacturer's specification.

d. Connect the nozzle holder with the delivery line to the tester.

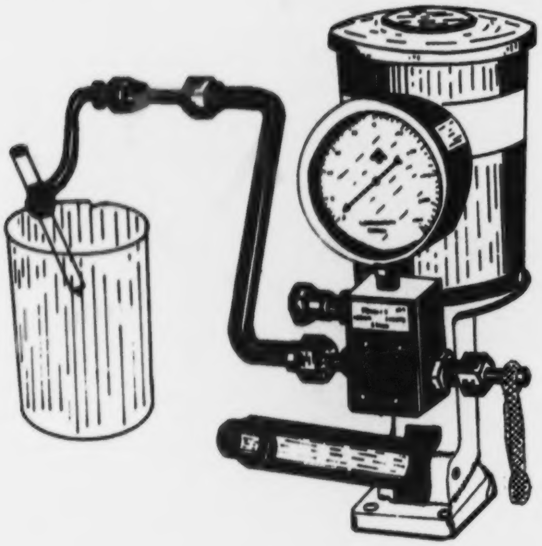
e. Look up and record opening pressure spec's. ______________

JOB SHEET #2

f. Enclose nozzle in transparent beaker, if possible. (Figure 2)

(CAUTION: The fuel comes out of nozzle at extremely high pressure which can penetrate clothing and skin and cause injury; always keep the nozzle pointed away from you or enclose in beaker.)

FIGURE 2



g. Test for nozzle jamming by pressing hand lever of nozzle tester down quickly (6-8 times) with the pressure gauge bypassed.

(NOTE: When valve moves properly, the nozzle should chatter with a shrill whistling buzz; an exception to the rule is the type nozzle with one or two small spray holes that will not chatter when lever is operated quickly.)

h. Open pressure gauge.

i. Depress hand lever slowly until the nozzle ejects with slight chatter.

j. Take reading of opening pressure on the pressure gauge.

(NOTE: Adjust to opening pressure specified in the engine operating instructions.)

JOB SHEET #2

k. Turn adjusting screw (Figure 3), or change total shim thickness (Figure 4), if reading differs from specified opening pressure.

(NOTE: Opening pressure is not adjusted by shims on all models.)

FIGURE 3

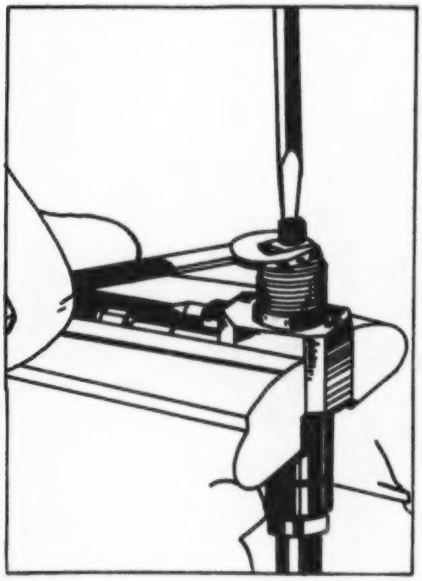
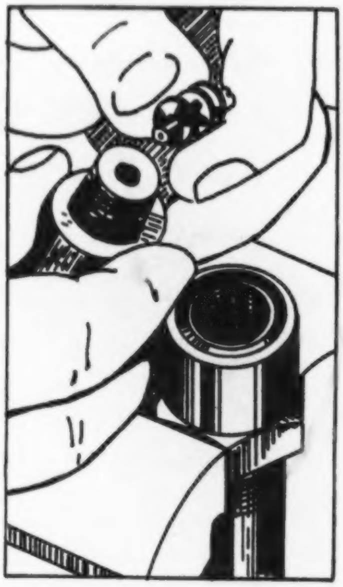


FIGURE 4



4. Test leakage — Operate the hand lever of the nozzle tester until the pointer on the pressure gauge indicates ______________ psi below the specified opening pressure indicated in the service manual.

(NOTE: The nozzle is considered leakproof if no oil emerges at the nipple tip within 10 seconds.)

INJECTION NOZZLES
UNIT II

JOB SHEET #3 — INSTALL AN INJECTION NOZZLE

A. Tools and materials

1. Basic shop tools
2. Appropriate service manual
3. Cleaning solvent
4. Torque wrench
5. Typical tools as required

B. Procedure

(CAUTION: Follow all shop safety procedures.)

1. Clean nozzle in diesel fuel.
2. Clean area around nozzle (seat or bore).
3. Clean nozzle tube of any foreign material.
4. Install new seal washer.
5. Place nozzle carefully in cylinder head.
6. Tighten nozzle hold-down bolts evenly.
7. Torque nozzle bolts or nuts to manufacturer's specifications.

   (NOTE: Use anti-seize on threads.)
8. Connect fuel lines to injector.
9. Torque fuel lines to manufacturer's specifications.

   (CAUTION: Do not overtighten fuel line[s] as this will damage fuel line.)

INJECTION NOZZLES
UNIT II

PRACTICAL TEST
JOB SHEET #1 — ISOLATE A FAULTY INJECTION NOZZLE

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ____________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Found faulty injector.	______	______
3. Removed and repaired faulty injector.	______	______
4. Checked in/put away tools and materials.	______	______
5. Cleaned the work area.	______	______
6. Used proper tools correctly.	______	______
7. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
8. Practiced safety rules throughout procedure.	______	______
9. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #1 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

	4	3	2	1
Found the faulty nozzle				

EVALUATOR'S COMMENTS: ____________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

INJECTION NOZZLES
UNIT II

PRACTICAL TEST
JOB SHEET #2 — REMOVE, SERVICE, AND TEST AN INJECTION NOZZLE

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ______________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:		YES	NO
1.	Checked out proper tools and materials.	______	______
2.	Cleaned the area around the nozzle.	______	______
3.	Removed and capped injector and leak-off lines.	______	______
4.	Cleaned nozzle.	______	______
5.	Cleaned spray tip with a brass brush.	______	______
6.	Checked injector for proper opening pressure.	______	______
7.	Checked injector leak-off.	______	______
8.	Checked in/put away tools and materials.	______	______
9.	Cleaned the work area.	______	______
10.	Used proper tools correctly.	______	______
11.	Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
12.	Practiced safety rules throughout procedure.	______	______
13.	Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #2 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:				
	4	3	2	1
Determined condition of nozzle				

EVALUATOR'S COMMENTS: ____________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

INJECTION NOZZLES
UNIT II

PRACTICAL TEST
JOB SHEET #3 — INSTALL AN INJECTION NOZZLE

STUDENT'S NAME ______________________ DATE __________

EVALUATOR'S NAME ______________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Cleaned nozzle and seat.	______	______
3. Installed new seal washer.	______	______
4. Tightened nozzle bolts or nuts to manufacturer's specifications.	______	______
5. Used anti-seize properly.	______	______
6. Torqued fuel drives to manufacturer's specifications.	______	______
7. Checked in/put away tools and materials.	______	______
8. Cleaned the work area.	______	______
9. Used proper tools correctly.	______	______
10. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
11. Practiced safety rules throughout procedure.	______	______
12. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #3 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

	4	3	2	1
Nozzle functioned properly, opening pressure O.K., no leaks				

EVALUATOR'S COMMENTS: ____

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

INJECTION NOZZLES
UNIT II

NAME ______________________________ SCORE ________________________

TEST

1. Match the terms on the right with their correct definitions.

    _____a. Valve in which the end extends into a shank or pin

    _____b. Small hole

    _____c. Nozzle, nozzle holder, valve, and spring assembly

    _____d. Valve, body, and spray valve

    1. Injection nozzle
    2. Nozzle assembly
    3. Orifice
    4. Pintle

2. List two functions of an injection nozzle.

    a. ____

    b. ____

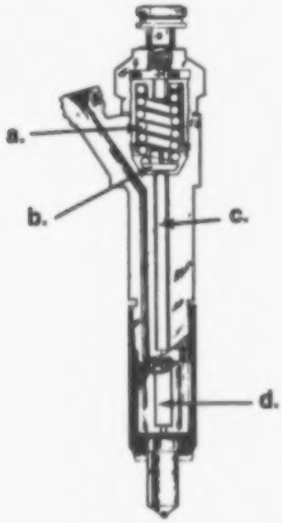
3. Identify the four moving parts in an injection nozzle.

    a. ____

    b. ____

    c. ____

    d. ____



TEST

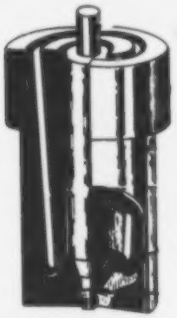
4. Identify three common types of nozzle valves.

   a. ____

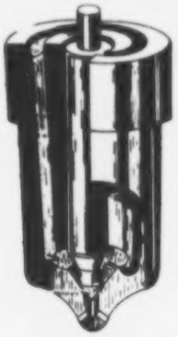
   b. ____

   c. ____

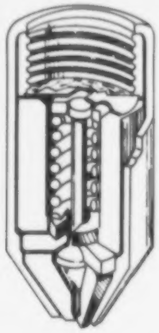
a.



b.



c.



5. Match the types of nozzles on the right with their characteristics.

   ______a. Used for engines with precombustion chambers

   ______b. Produces a hollow spray; used for engines with precombustion chambers

   ______c. Does not dribble fuel; used for engines with precombustion chamber

   ______d. Has several small holes; holes have a tendency to clog

   1. Hole type
   2. Multiple orifice
   3. Pintle type (inward-opening)
   4. Pintle type (outward-opening)

6. Select true statements concerning the operation of an injection nozzle by placing an "X" beside each statement that is true.

   ______a. Hydraulically or pressure operated by fuel delivered from the injection pump

   ______b. Spring loaded valve is lifted allowing pressurized fuel to spray out through one or more orifices into combustion chamber

7. Explain how the nozzle opening pressure is adjusted.

   ____

   ____

TEST

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

8. Demonstrate the ability to:
   a. Isolate a faulty injection nozzle. (Job Sheet #1)
   b. Remove, service, and test an injection nozzle. (Job Sheet #2)
   c. Install an injection nozzle. (Job Sheet #3)

INJECTION NOZZLES
UNIT II

ANSWERS TO TEST

1. a. 4
   b. 3
   c. 1
   d. 2

2. a. Atomizes the fuel for better combustion
   b. Spreads the fuel spray to fully mix with air

3. a. Spring
   b. Retainer
   c. Spindle
   d. Valve

4. a. Single hole, pintle
   b. Multiple orifice
   c. Single hole, capsule

5. a. 1
   b. 3
   c. 4
   d. 2

6. a, b

7. Adjusted by a screw or shims on the valve spring

8. Performance skills evaluated to the satisfaction of the instructor

DISTRIBUTOR TYPE INJECTION PUMP
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to remove, bench test, and install a distributor type pump. Competencies will be demonstrated by completing the job sheets and the unit tests with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to a distributor type injection pump with the correct definitions.
2. Identify the main parts of a distributor type pump.
3. Name three rotating parts of a distributor type pump.
4. Match the main parts of a distributor type pump with functions.
5. Select true statements concerning the principles of operation of a distributor type pump.
6. Complete statements concerning the flow of fuel during a complete pump cycle on a distributor type pump.
7. Select true statements concerning charging cycle operation.
8. Complete a list of statements concerning discharge cycle operation.
9. Select true statements concerning delivery valve operation.

OBJECTIVE SHEET

10. Select true statements concerning return fuel oil circuit functions.
11. Name three functions of an end plate.
12. Complete a list of optional features of a distributor type pump.
13. Demonstrate the ability to:
    a. Remove a distributor type pump from an engine. (Job Sheet #1)
    b. Bench test a distributor type pump. (Job Sheet #2)
    c. Install a distributor type pump on an engine. (Job Sheet #3)

DISTRIBUTOR TYPE INJECTION PUMP
UNIT III

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in this unit of instruction.

(NOTE: This activity should be completed prior to the teaching of this unit.)

B. Make transparencies from the transparency masters included with this unit.

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information sheet.

F. Discuss information sheet.

(NOTE: Use the transparencies to enhance the information as needed.)

G. Provide students with job sheets.

H. Discuss and demonstrate the procedures outlined in the job sheets.

I. Integrate the following activities throughout the teaching of this unit:

  1. Discuss disassembly of an injection pump.
  2. Have students look up calibration data.
  3. Show actual components.
  4. Show film about injection pump.
  5. Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas for improvement.

J. Give test.

K. Evaluate test.

L. Reteach if necessary.

REFERENCES USED IN DEVELOPING THIS UNIT

A. Dagel, John F. *Diesel Engine Repair.* New York, NY: John Wiley and Sons, Inc., 1982.

B. *Fundamentals of Service: Engines.* 5th ed. Moline, IL: Deere and Company, 1980.

C. Kates, Edgar J., and William E. Luck. *Diesel and High Compression Gas Engines.* 3rd ed. Chicago: American Technical Society, 1984.

D. *Roosa Master: Operation and Instructional Manual: Model DP Pump.* Hartford, CT: Stanadyne/Hartford Division/Roosa Master.

E. Schulz, Erich J. *Diesel Mechanics.* 2nd ed. Dallas, TX: McGraw-Hill, 1983.

SUGGESTED SUPPLEMENTAL RESOURCES

Texts

A. *6.9L Diesel Engine*

B. *Diesel Fuel and Electrical System Diagnosis*

(NOTE: Contact your nearest Ford dealer or training center for additional information.)

Filmstrip

The GM Diesel Engine Fuel Injection Pump
P-02-09431
Teaching Aids, Inc.
P.O. Box 1798
Costa Mesa, CA 92628-0798

DISTRIBUTOR TYPE INJECTION PUMP
UNIT III

INFORMATION SHEET

I. **Terms and definitions**

   A. Aneroid — Pressure measuring device

   B. Annulus — Ring; a part, structure, or marking resembling a ring

   C. Circuit — Complete path of fuel flow

   D. Delivery valve — Provides retraction of delivery line pressure causing nozzle valve to return to its seat, preventing dribble of fuel into combustion chamber

   E. Distributor type injection system — Normally uses two or four plunger pump to distribute fuel to all cylinders

   (NOTE: Stanadyne and CAV are opposed plunger design.)

   F. Governor — A speed-sensing device that employs centrifugal force and spring tension to govern the engine speed

   G. Hydraulic — Operated or moved by liquid in motion

   H. Metering — Precision measurement of fuel delivery

   I. Registry — Oil passage that indexes with a port in a rotating head

   J. Retraction — Act of drawing back

   K. Servomechanism — Automatic device for controlling large amounts of power with small amounts of power as a piston moved by fluid under pressure

II. **Main parts of distributor type pump** (Transparency 1)

   A. Drive shaft

   B. Distributor rotor

   C. Transfer pump

   D. Pumping plungers

   E. Internal cam-ring

   F. Annulus in hydraulic head

   G. End plate

INFORMATION SHEET

H. Governor

I. Automatic advance

J. Housing

III. **Rotating parts of distributor type pump** (Transparency 1)

A. Drive shaft

B. Distributor rotor

C. Transfer pump blades

IV. **Functions of main parts** (Transparency 1)

A. Drive shaft — Turns distributor rotor in the hydraulic head

B. Distributor rotor — Rotation of rotor causes pumping action of plungers which discharge fuel when passages index with appropriate passages in the hydraulic head

C. Transfer pump — Draws fuel from supply tank through inlet strainer to pump

(NOTE: Vane type pump is attached to opposite end of distributor rotor.)

D. Pumping plungers — Provide pressure to transfer fuel from rotor to hydraulic head to injection nozzles

E. Internal cam ring — Actuates the pumping plungers

F. Hydraulic head — Contains the metering valve and the bore in which the rotor revolves

G. End plate — Houses the transfer pump pressure regulating valve and fuel strainer

H. Governor — Regulates the speed by positive mechanical linkage to metering valve

I. Automatic speed advance — Hydraulic servomechanism powered by oil pressure from the transfer pump which advances injection timing

(NOTE: Not all pumps are equipped with an automatic speed advance.)

J. Housing — Contains all component parts

INFORMATION SHEET

V. **Principles of operation of distributor type pump** (Transparency 1)

A. Drive shaft engages the distributor rotor in the hydraulic head.

(NOTE: Drive end of rotor has two cylinder bores, each containing two plungers.)

B. Plungers are actuated toward each other simultaneously by the internal cam-ring to pump fuel.

C. As rotor revolves inside hydraulic head, the discharge passage in the rotor indexes with appropriate passage in the hydraulic head to lead to the injector nozzles.

VI. **Fuel flow** (Transparency 2)

A. Fuel is drawn from the supply tank into the pump through the inlet strainer by the vane type fuel transfer pump.

B. Transfer pump pressure forces fuel through drilled passages in the hydraulic head into the annulus.

C. Transfer pump pressure increases with speed.

D. Fuel flows around the annulus to top of sleeve and through connecting passages to metering valve.

E. Metering valve regulates the flow of fuel into the charging ring which incorporates the charging ports.

F. As the rotor revolves, the twin inlet passages register with two charging ports in the hydraulic head allowing fuel to flow into the pumping cylinders.

G. With further rotation, the inlet passages move out of registry, and the single discharge port is opened.

H. The rollers contact the cam lobes forcing the plungers together.

I. Fuel trapped between the plungers is then delivered through delivery valve to the nozzle.

VII. **Charging cycle operation** (Transparency 2)

A. When the rotor revolves, the angled inlet passages in the rotor line up with the charging ports of the charging ring.

B. Pressurized fuel from the transfer pump, controlled by the opening of the metering valve, flows to the pumping cylinders forcing all plungers apart.

INFORMATION SHEET

C. The plungers move outward enough to supply the correct quantity of fuel for the engine load.

(NOTE: At idle the plungers would move very little, whereas at maximum load, they would go into full fuel position.)

VIII. **Discharge cycle operation** (Transparency 3)

A. As the rotor continues to revolve, the angled inlet passages no longer line up with the charging ports.

B. Fuel is momentarily trapped until the rotor discharge passage lines up with one of the head outlets.

C. The rollers contact the cam lobes and are forced together.

D. Fuel is then forced through the axial passage of the rotor, then to the injection line.

E. Delivery of the fuel will continue until the rotors pass the high point on the cam.

F. The fuel pressure in the axial passage is then reduced to a point where the injection nozzle closes.

IX. **Delivery valve operation** (Transparency 4)

A. Controlled line retraction is the most important job of the delivery valve; this is accomplished by reducing injection line pressure to a point lower than that of the nozzle closing pressure.

B. The delivery valve is located in a drilled passageway in the center of the rotor.

C. There is only one delivery valve, so all cut-off points will be the same.

D. As injection begins, fuel pressure moves the delivery valve off its shoulder to allow the volume of its displacement to enter the cavity that houses the delivery valve spring.

E. This displaces a similar volume of fuel in the spring cavity before delivery starts through the valve ports.

F. At the end of injection, the pressure on the plunger side of the delivery valve is reduced, allowing the cam rollers to fall into the retraction step of the cam lobes.

G. As the valve moves back, the fuel is removed from the spring cavity and flows through the rotor discharge port; then, as the rotor revolves, it is trapped.

INFORMATION SHEET

X. **Return fuel oil circuit functions**

   A. Transfer pump pressure is discharged into a cavity in the hydraulic head.

   B. The upper part of this cavity has a vent passage connected to it.

   C. Should air enter the transfer pump, it will be bled off and returned to the fuel tank.

XI. **Functions of end plate** (Transparency 5)

   A. Provides fuel inlet passages and houses pressure regulating valve

   B. Covers the fuel transfer pump

   C. Absorbs end thrust of drive and governor

XII. **Optional features of a distributor type pump** (Transparencies 6 and 7)

   A. Viscosity compensator

   B. Centrifugal governor

   C. Automatic load advance

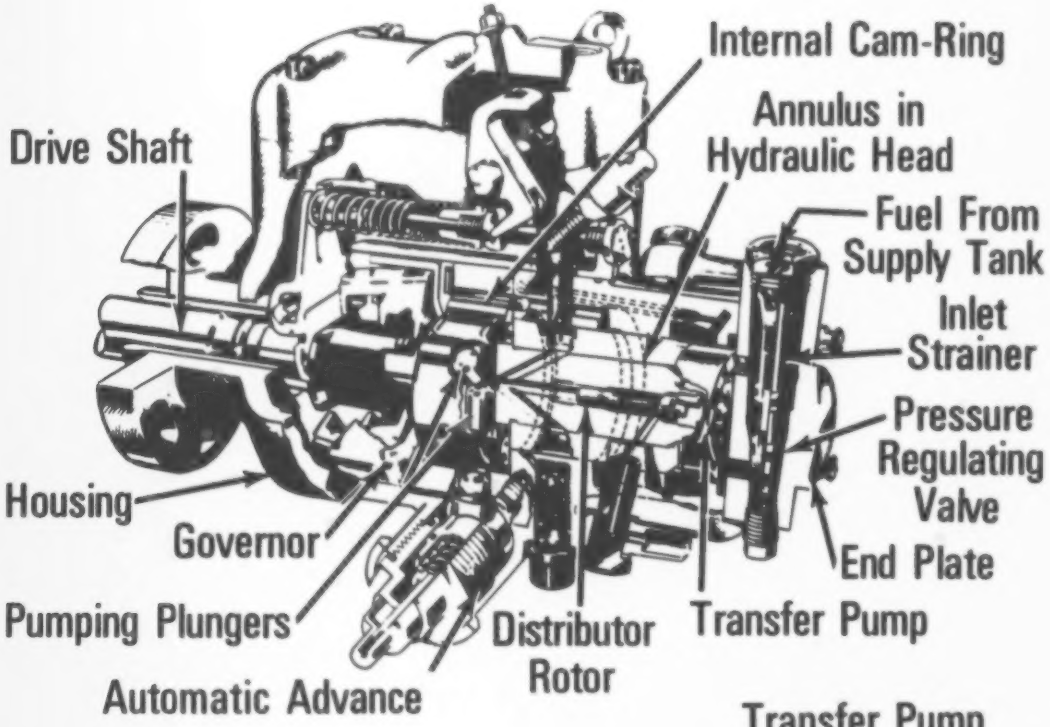
   D. Automatic speed advance

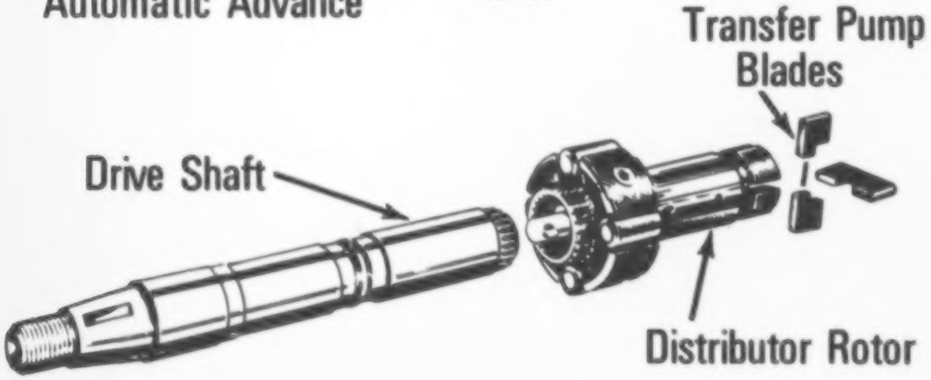
   E. Torque control

   F. Electric shut-off

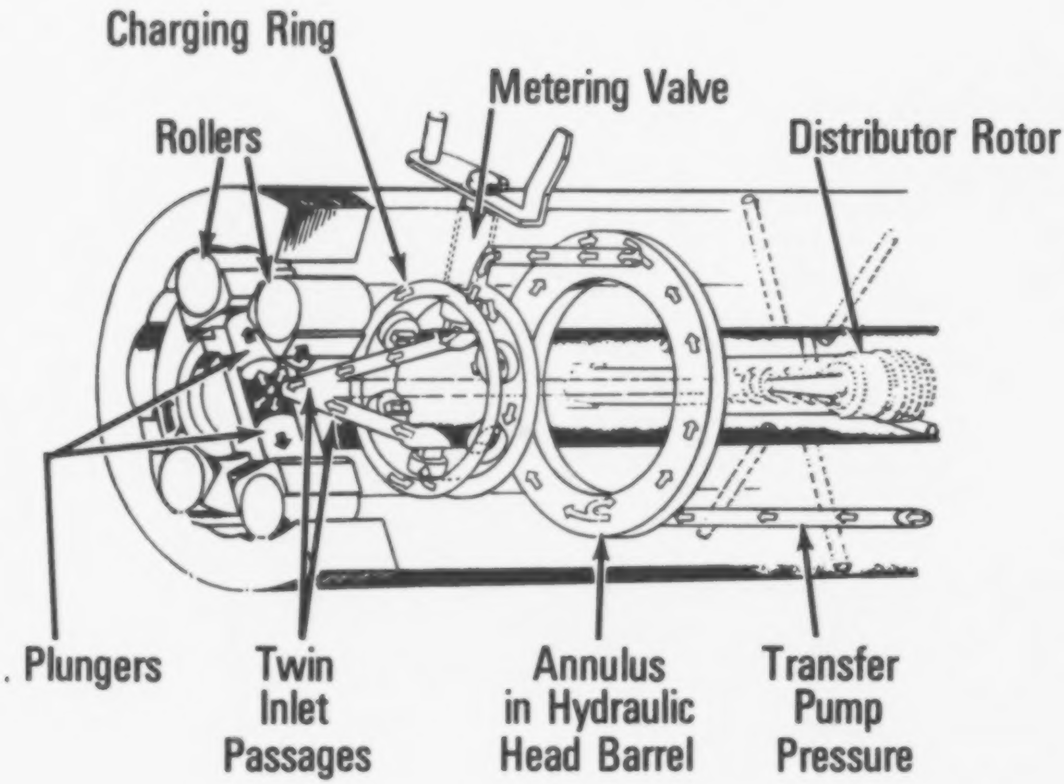
   G. Aneroid

Main Parts of Distributor Type Pump


Internal Cam-Ring
Annulus in Hydraulic Head
Drive Shaft
Fuel From Supply Tank
Inlet Strainer
Pressure Regulating Valve
Housing
Governor
End Plate
Pumping Plungers
Distributor Rotor
Transfer Pump
Automatic Advance


Transfer Pump Blades
Drive Shaft
Distributor Rotor

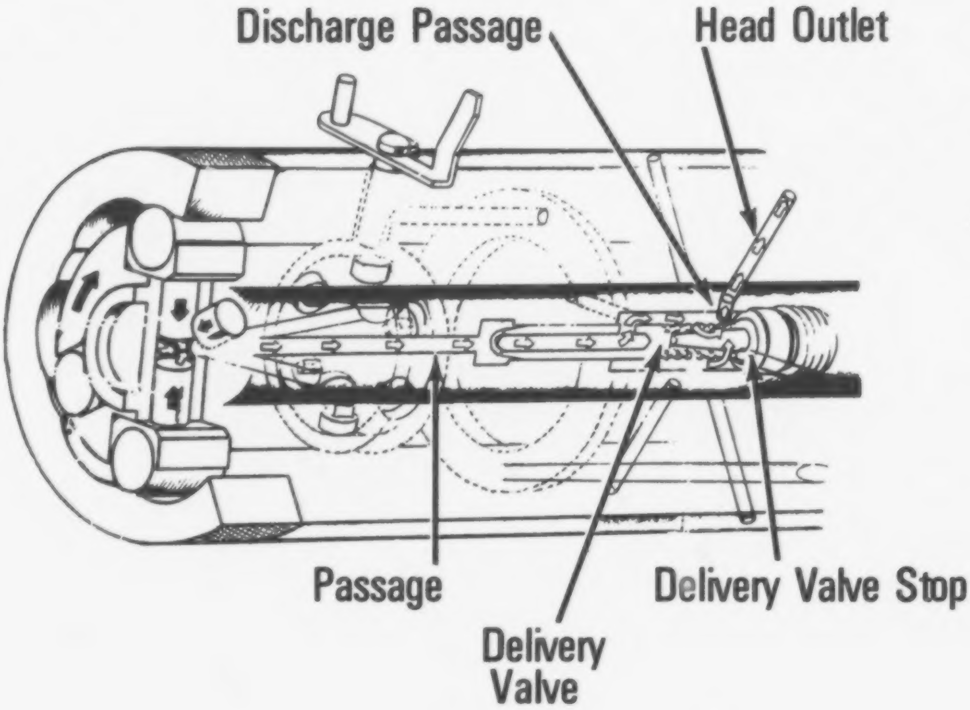
Fuel Flow


Charging Ring
Metering Valve
Rollers
Distributor Rotor
. Plungers
Twin Inlet Passages
Annulus in Hydraulic Head Barrel
Transfer Pump Pressure

Charging Cycle

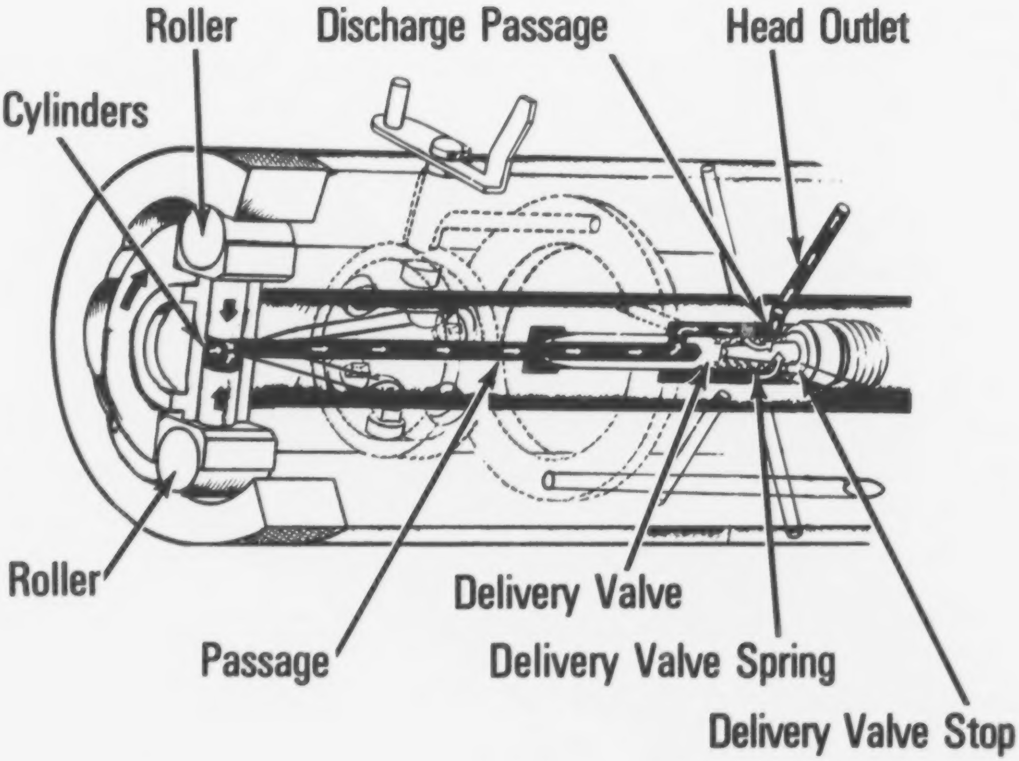
Fuel Flow

(Continued)

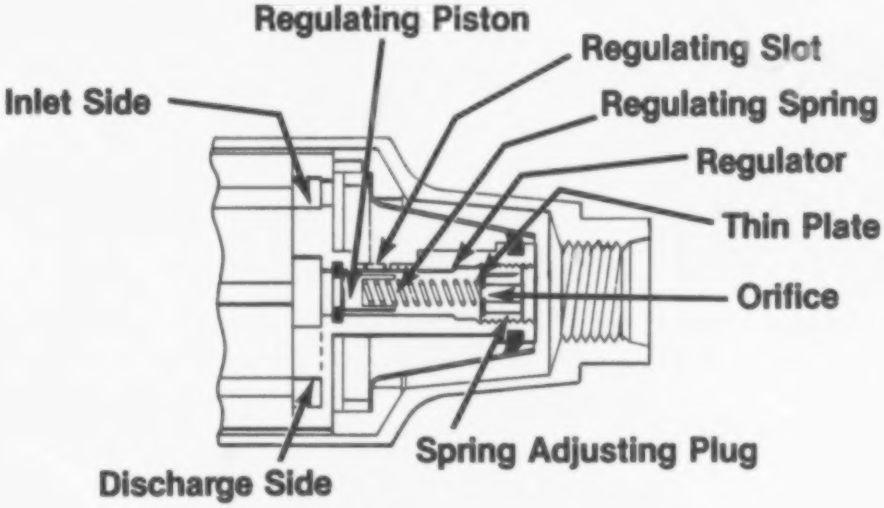

Discharge Passage
Head Outlet
Passage
Delivery Valve Stop
Delivery Valve

Discharge Cycle

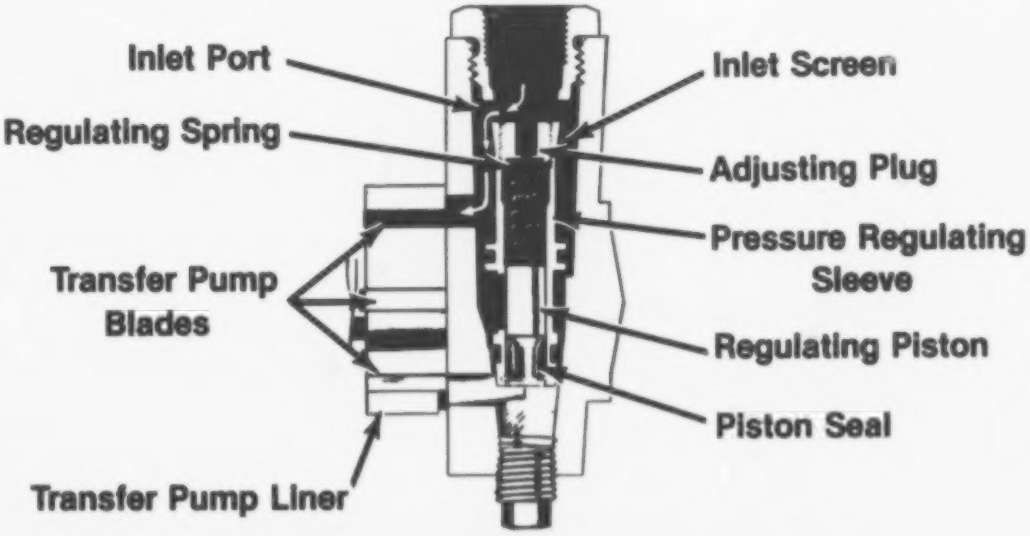
Delivery Valve Operation


Roller
Discharge Passage
Head Outlet
Cylinders
Roller
Delivery Valve
Passage
Delivery Valve Spring
Delivery Valve Stop

Transfer Pump Assemblies


Regulating Piston
Regulating Slot
Inlet Side
Regulating Spring
Regulator
Thin Plate
Orifice
Spring Adjusting Plug
Discharge Side

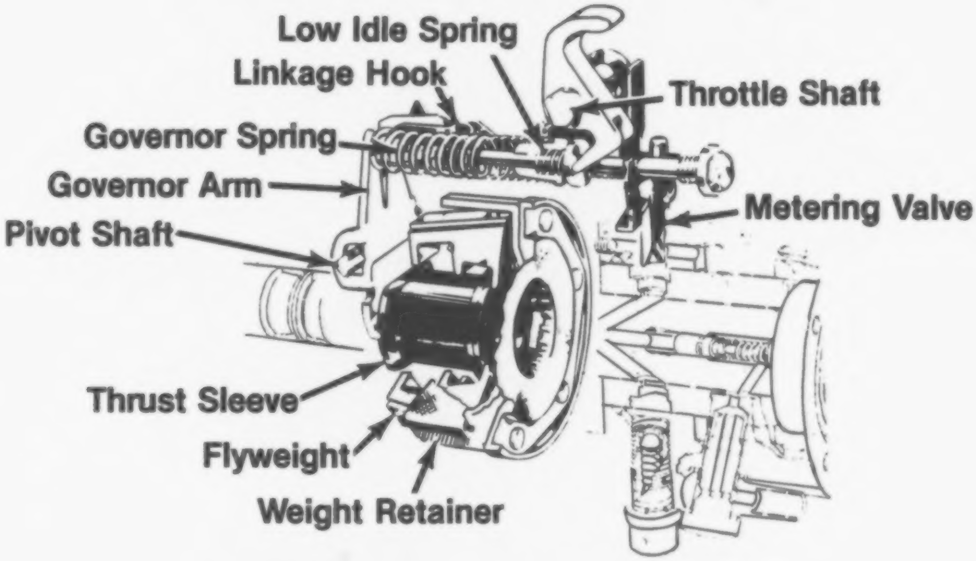
End Cap Type


Inlet Port
Inlet Screen
Regulating Spring
Adjusting Plug
Pressure Regulating Sleeve
Transfer Pump Blades
Regulating Piston
Piston Seal
Transfer Pump Liner

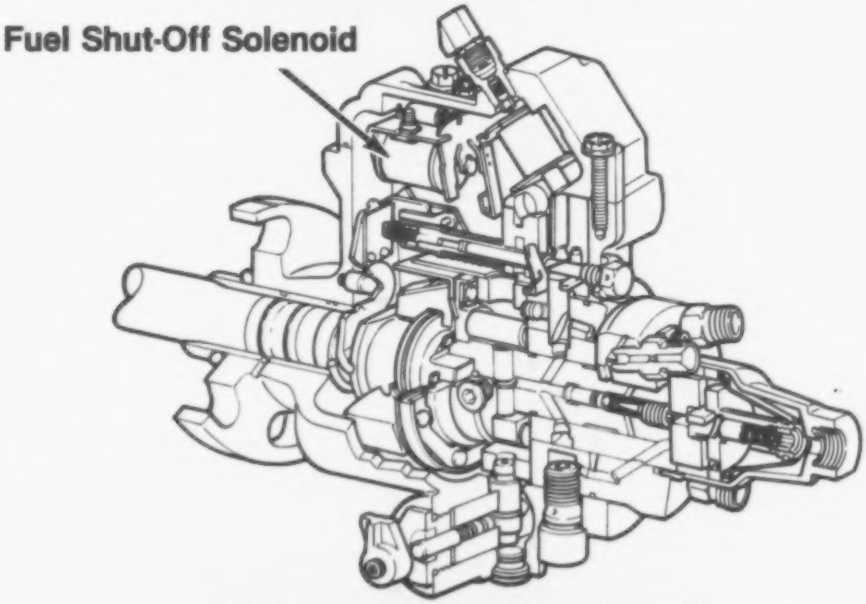
End Plate Type

Courtesy of Stanadyne Diesel Systems

Optional Features of a Distributor Type Pump


Low Idle Spring
Linkage Hook
Throttle Shaft
Governor Spring
Governor Arm
Metering Valve
Pivot Shaft
Thrust Sleeve
Flyweight
Weight Retainer

Centrifugal Governor


Fuel Shut-Off Solenoid

Electrical Shut-Off

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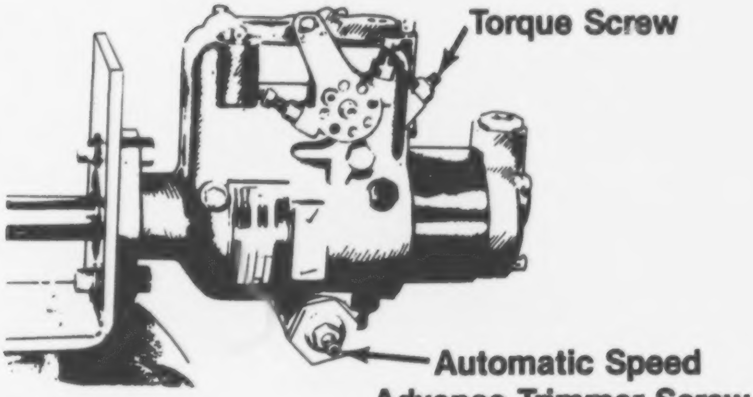
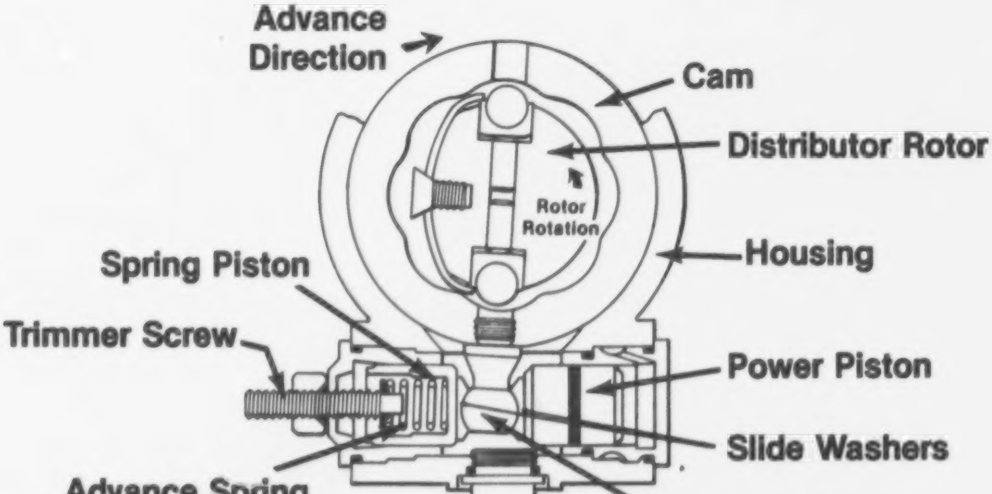
Optional Features of a Distributor Type Pump

(Continued)


Torque Screw
Automatic Speed Advance Trimmer Screw

Torque Control Screw


Advance Direction
Cam
Distributor Rotor
Rotor Rotation
Housing
Spring Piston
Trimmer Screw
Power Piston
Slide Washers
Advance Spring
Advance Cam Screw

Automatic Advance Mechanism

Courtesy of Stanadyne Diesel Systems

DISTRIBUTOR TYPE INJECTION PUMP
UNIT III

JOB SHEET #1 — REMOVE A DISTRIBUTOR TYPE PUMP FROM AN ENGINE

A. Tools and materials

1. Distributor type pump
2. Appropriate service manual
3. Hand tool set
4. Solution for washing pump
5. Shop towels (lint-free)
6. Shipping caps or plugs for disconnected lines
7. Safety glasses

B. Procedure

(CAUTION: Follow all shop safety procedures.)

1. Make preliminary checks before condemning pump. If pump is bad, continue with the following steps. If pump is good, then troubleshoot the system to determine problem.

   (NOTE: Refer to engine manual and determine type pump installation. If drive shaft is part of engine drive assembly, it remains with the engine.)

2. Clean and wash down pump, fittings, and all connections to be broken to eliminate any chance of dirt entering the system when lines are disconnected.

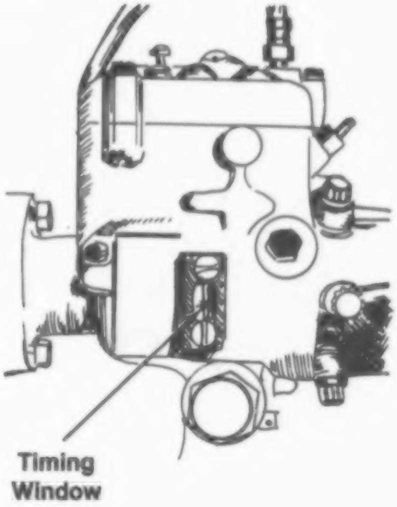
   (CAUTION: All openings should be temporarily plugged as lines are disconnected.)

3. Check the engine manual for proper timing position of crankshaft.
4. Bar the engine in correct direction of rotation until the engine timing mark is indexed and the #1 cylinder is on *compression stroke.*

JOB SHEET #1

5. Remove the timing window cover from the outboard side of the pump. (Figure 1)

FIGURE 1



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(NOTE: The timing line on the governor weight retainer hub should be directly opposite the line on the cam. To verify static timing, remove #1 injector line from #1 injector and rotate engine slowly in direction of rotation; when a drop of fuel comes out of line, check timing mark to see if it is within specification.)

6. Disconnect the fuel supply, return, and nozzle leak-off lines and all high pressure lines, plugging all openings.

(CAUTION: Do not bend or twist high pressure lines.)

7. Disconnect throttle and shut-off linkage.

8. Tie throttle lever in full fuel position.

9. Remove mounting nuts on the pump flange.

10. Slide pump gently from location.

(CAUTION: Be careful not to damage the pilot tube by cocking pump on removal.)

DISTRIBUTOR TYPE INJECTION PUMP
UNIT III

JOB SHEET #2 — BENCH TEST A DISTRIBUTOR TYPE PUMP

A. Tools and materials

1. Distributor type pump
2. Appropriate service manual
3. Hand tool set
4. Injection line — 1/16" I.D. × 20" length
5. Injection line — 3/32" I.D. × 20" length
6. Calibrating nozzles adjusted to pump manufacturer's specifications
7. Pump test stand
8. Adapters — pump to test stand
9. Recommended calibrating oil
10. Shop towels (lint-free)
11. Safety glasses

JOB SHEET #2

B. Procedure

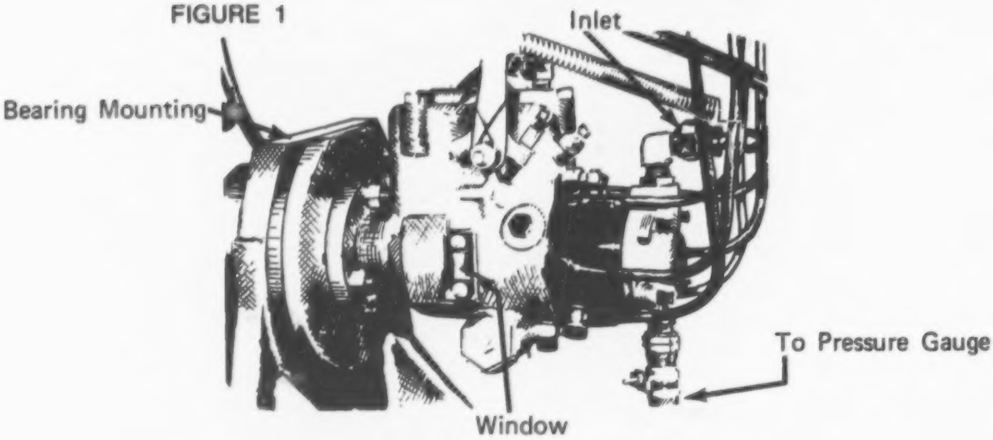
(CAUTION: Follow all shop safety procedures.)

1. Calibrate and test.

   a. Mount the pump securely with appropriate adapters.

   (NOTE: If pump employs a steel pilot tube, do not support the drive shaft in the housing. A drive adapter, usually with a ball bearing, supports the shaft. These pumps must be tested using an intermediate support bearing. See Figure 1.)

   FIGURE 1



   b. Install high pressure injection lines using new gaskets.

   (NOTE: Install two new gaskets, one on each side of fitting. Leave fuel line connector screws at pump and injection line nuts at nozzles loose. Failure to do this will cause pump seizure.)

   c. Install inlet and return lines and transfer pump pressure gauge.

   (NOTE: Use a restriction fitting on the return line if the pump normally uses one.)

   d. Determine proper direction of rotation from pump name plate. ("C" — Clockwise, "CC" — Counterclockwise)

   (NOTE: Rotation is determined as viewed from drive end of pump.)

   e. Start stand at lowest speed, and move throttle to "full-load" position.

   f. Allow fuel to bleed for several seconds from loosened connector screws when transfer pump picks up suction.

JOB SHEET #2

g. Allow fuel to bleed from loosened injection line nuts; then, tighten securely.

(NOTE: If pump is factory tested on stands which measure fuel flow in cubic millimeters, it is necessary to convert the readings on other types of stands which measure in cubic centimeters. See Figure 2.)

FIGURE 2

Delivery in Each Graduate (CC's)	Delivery in Cubic Millimeters (MM^3) per Stroke								
	Numbered Strokes								
	25	100	125	200	250	300	400	500	1000
1	40	10	8	5	4	3.3	2.5	2	1(mm^3)
2	80	20	16	10	8	6.7	5.0	4	2
3	120	30	24	15	12	10.0	7.5	6	3
4	160	40	32	20	16	13.3	10.0	8	4
5	200	50	40	25	20	16.7	12.5	10	5
6	240	60	48	30	24	20.0	15.0	12	6
7	280	70	56	35	28	23.3	17.5	14	7
8	320	80	64	40	32	26.7	20.0	16	8
9	360	90	72	45	36	30.0	22.5	18	9
10	400	100	80	50	40	33.3	25.0	20	10
20		200	160	100	80	66.7	50.0	40	20
30		300	240	150	120	100.0	75.0	60	30
40		400	320	200	160	133.3	100.0	80	40
50			400	250	200	166.7	125.0	100	50
60				300	240	200.0	150.0	120	60
70				350	280	233.3	175.0	140	70
80				400	320	266.7	200.0	160	80
90					360	300.0	225.0	180	90
100					400	333.3	250.0	200	100

(NOTE: The test stand tachometer registers pump speed. Some specification test data refers to engine speed. Pump speed is ½ engine speed.)

h. Operate pump at 1000 rpm for 10 minutes.

i. Dry off completely with compressed air.

j. Observe for leaks and correct as necessary.

k. Back out the high idle stop screw and torque screw, if equipped.

(NOTE: The inlet to the transfer pump should never be pressurized during bench testing.)

l. Close valve in supply line.

(NOTE: Check to see that transfer pump pulls up to manufacturer's specifications. If it does not, check for air leaks on suction side or malfunction of end plate and transfer pump parts. If the pump is equipped with an external by-pass, it should be pinched off during this test.)

JOB SHEET #2

m. Fill graduates to bleed air from test stand and to wet glass.

n. Observe return oil.

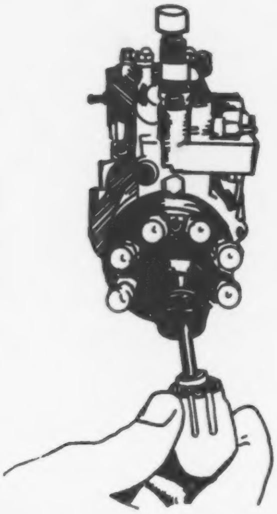
(NOTE: Compare observable return with manufacturer's specifications. By-pass equipped pumps will return less fuel.)

o. Operate the specified speeds with wide open throttle, and observe transfer pump pressure.

(NOTE: Adjust pressure regulating spring plug to raise or lower transfer pump pressure.)

(CAUTION: Under no circumstances should 130 psi be exceeded. See Figure 3.)

FIGURE 3



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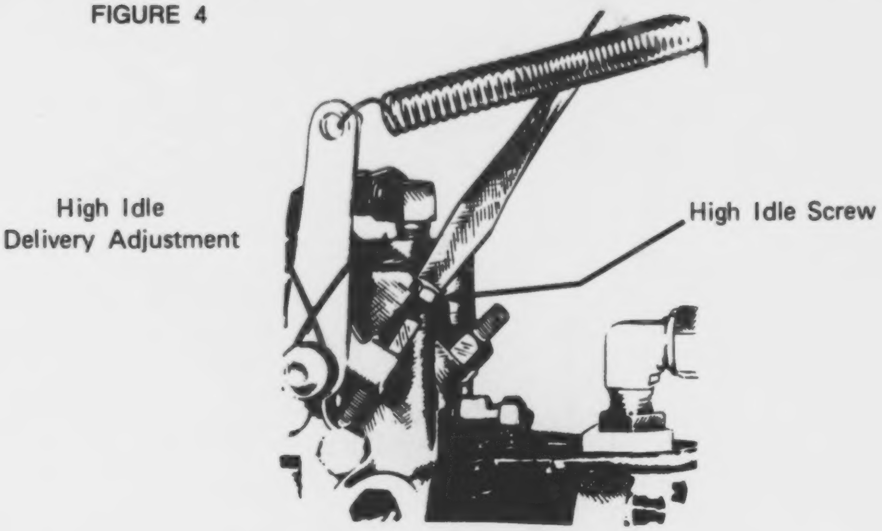
p. Check for minimum delivery at cranking speed.

JOB SHEET #2

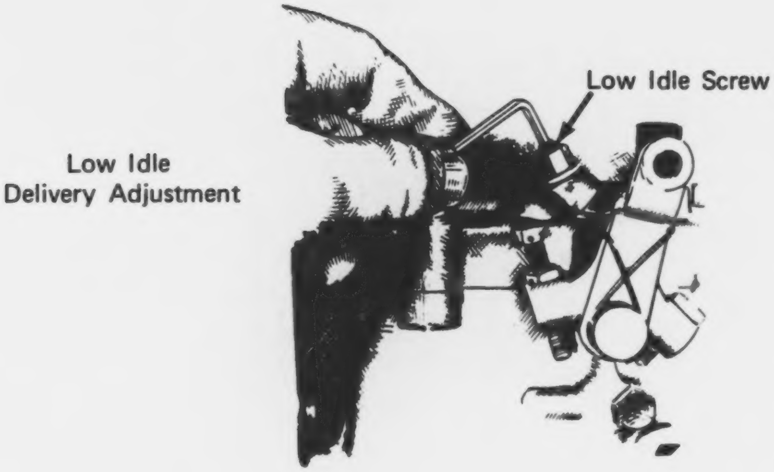
q. Operate at high idle speed and adjust high idle screw to obtain the specified delivery. (Figure 4)

FIGURE 4


High Idle
Delivery Adjustment
High Idle Screw

r. Adjust the low idle screw to the correct low idle delivery. (Figure 5)

FIGURE 5


Low Idle Screw
Low Idle
Delivery Adjustment

JOB SHEET #2

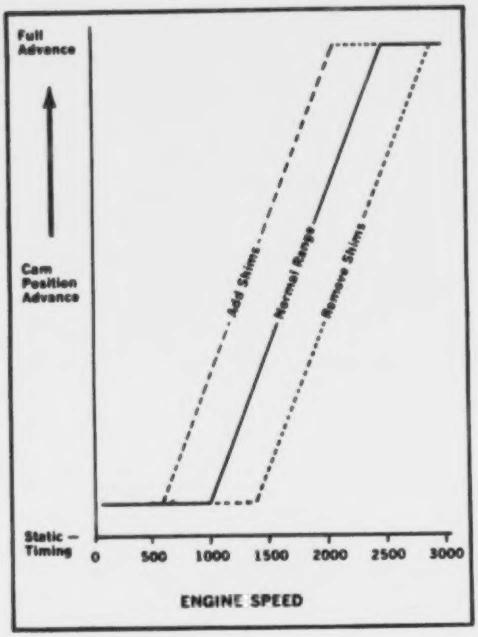
s. Adjust automatic advance.

1) Adjust speed advance.

a) Check the cam position at specified points in the speed range.

b) Adjust trimmer screw, or shim, as required to obtain proper advance operation. (Figure 6)

FIGURE 6



2) Adjust load advance.

a) Adjust the test stand speed to the specified part-load delivery.

b) Observe cam position, and adjust guide stud for correct cam movement. (Figures 7 and 8)

JOB SHEET #2

FIGURE 7

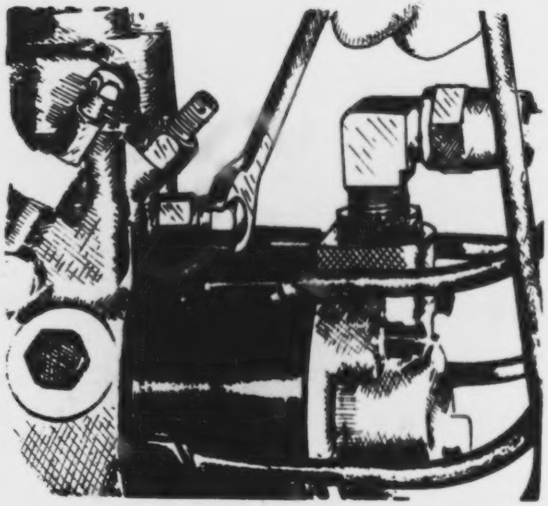
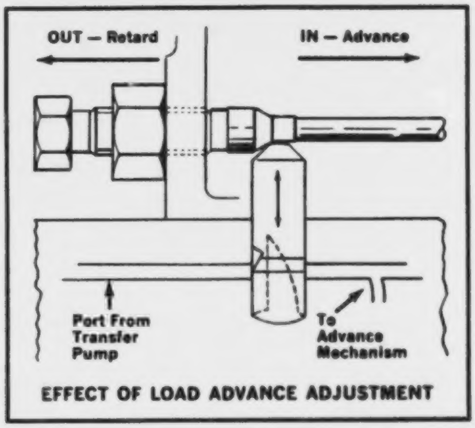

Load Advance
Adjustment

FIGURE 8


OUT — Retard
IN — Advance
Port From Transfer Pump
To Advance Mechanism

EFFECT OF LOAD ADVANCE ADJUSTMENT

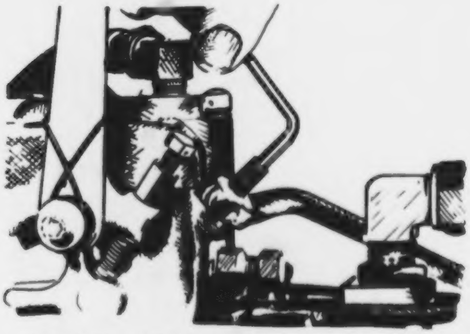
t. Record fuel delivery at check points shown on the pump specification.

(NOTE: ROLLER SETTINGS SHOULD NOT BE READJUSTED ON THE TEST BENCH. Experience has proven that micrometer and dial indicator settings provide more consistent, accurate results in performance. Variations in test benches, nozzles, lines, and fuels in different areas sometimes result in inaccurate flow readings.)

JOB SHEET #2

u. Set torque screw (if employed) to specified delivery while operating at full-load governed speed. (Figure 9)

FIGURE 9



TORQUE SCREW ADJUSTMENT

v. Recheck delivery at lowest speed checkpoint.

w. Check governor cutoff at specified speed.

2. Remove from test stand and assemble all sealing wires; pump is now ready for installation to engine.

(NOTE: If there is no drive shaft with the pump, wire the throttle level in "full fuel" position for shipment or until installed on engine. Otherwise, mount the pump on drive adapter with shaft. Check shaft seals with a pressure test on the housing.)

DISTRIBUTOR TYPE INJECTION PUMP
UNIT III

JOB SHEET #3 — INSTALL A DISTRIBUTOR TYPE PUMP ON AN ENGINE

A. Tools and materials

1. Distributor type pump
2. Appropriate service manual
3. Drive shaft installation tool
4. Torque wrench
5. Safety glasses

B. Procedure

(CAUTION: Follow all shop safety procedures.)

(NOTE: Pumps marked "Timed Start Inj." or "Timed End Inj." on the timing window cover are timed according to procedures below.)

1. Remove outboard timing window cover (name plate side).

   (NOTE: On 6.2L Chevrolet and 6.9L Ford, the window is not used.)

2. Rotate the distributor rotor with a CLEAN, wide-blade screwdriver or the pump drive shaft inserted into the drive end of the pump until the timing line on the weight retainer hub registers with the line on the cam O.D.

   (NOTE: The pump is now correctly positioned for assembly to the engine.)

3. Roll the engine in direction of rotation until the flywheel is correctly positioned for fuel pump assembly. (See engine manual.)

4. Apply a light coat of grease to the drive shaft seals.

5. Compress the drive shaft seals with the drive shaft installation tool, and slide the pump into position over the mounting studs.

   (NOTE: Make sure drive shaft and seals are properly positioned.)

6. Assemble and tighten the mounting nuts finger tight.

JOB SHEET #3

7. Rotate pump, first in the direction of rotation and then in the opposite direction until timing lines again register. (Figures 1 and 2)

FIGURE 1

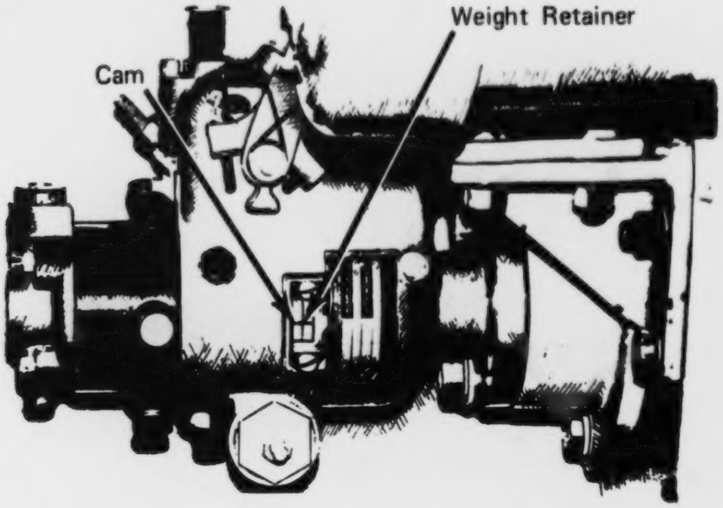
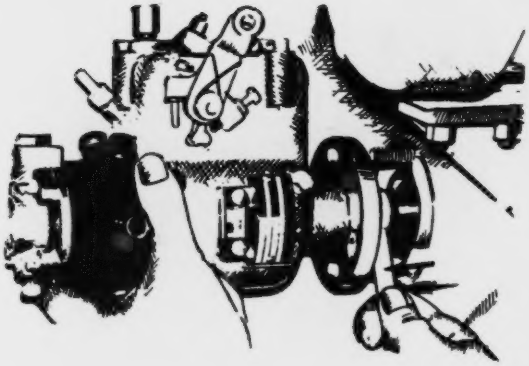


FIGURE 2



8. Tighten nuts securely to take up all back lash.

(CAUTION: Drive shaft spline should engage with hand pressure. Do not attempt to "draw up" the pump flange with mounting stud nuts. If spline does not engage, rotate pump slightly to locate timing pin.)

9. Back off engine at least ½ revolution, and roll it again in the direction of rotation to the proper timing mark.

(NOTE: Recheck line marks in the pump and correct if necessary. Repeat procedure to insure proper timing.)

JOB SHEET #3

10. Unplug open ends of high pressure lines, assemble with new fuel line connector washers, and tighten to specified torque.

11. Assemble and tighten fuel return and nozzle leak-off lines.

12. Attach pump controls.

13. Open bleed screw on secondary filter, and operate hand primer (if equipped) or allow fuel to flow from tank until all air is dispelled from filter.

14. Close bleed screw.

15. Continue hand priming until a quantity of fuel flows "air-free" at pump inlet line.

16. Fasten the inlet line to the pump.

    (NOTE: This procedure should also be followed without fail after every filter change. Refer to engine manual for starting instructions before starting engine.)

17. Provide means for emergency shut-off.

DISTRIBUTOR TYPE INJECTION PUMP
UNIT III

PRACTICAL TEST
JOB SHEET #1 — REMOVE A DISTRIBUTOR TYPE PUMP FROM AN ENGINE

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ____________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Cleaned and washed pump and engine.	______	______
3. Checked timing position.	______	______
4. Put engine on #1 compression stroke.	______	______
5. Removed timing window.	______	______
6. Disconnected all lines and fittings.	______	______
7. Disconnected linkage.	______	______
8. Tied throttle lever open.	______	______
9. Removed mounting nuts.	______	______
10. Removed pump.	______	______
11. Checked in/put away tools and materials.	______	______
12. Cleaned the work area.	______	______
13. Used proper tools correctly.	______	______
14. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
15. Practiced safety rules throughout procedure.	______	______
16. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #1 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:				
	4	3	2	1
Pump is clean and removed.				

EVALUATOR'S COMMENTS: ____

____

PERFORMANCE EVALUATION KEY
4 — Skilled — Can perform job with no additional training. 3 — Moderately skilled — Has performed job during training program; limited additional training may be required. 2 — Limited skill — Has performed job during training program; additional training is required to develop skill. 1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

DISTRIBUTOR TYPE INJECTION PUMP
UNIT III

PRACTICAL TEST
JOB SHEET #2 — BENCH TEST A DISTRIBUTOR TYPE PUMP

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ______________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Mounted pump.	______	______
3. Installed lines.	______	______
4. Determined rotation.	______	______
5. Started stand at low speed.	______	______
6. Bled pump.	______	______
7. Operated pump at 1000 rpm.	______	______
8. Dried with air.	______	______
9. Observed for leaks.	______	______
10. Backed out the high idle stop screw and torque screw.	______	______
11. Checked transfer pump vacuum.	______	______
12. Filled graduates to bleed air and wet glass.	______	______
13. Observed return oil.	______	______
14. Adjusted to manufacturer's specifications.	______	______
15. Checked in/put away tools and materials.	______	______
16. Cleaned the work area.	______	______
17. Used proper tools correctly.	______	______
18. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
19. Practiced safety rules throughout procedure.	______	______
20. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #2 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:				
No leaks	4	3	2	1
Pump is set within manufacturer's specifications.	4	3	2	1

EVALUATOR'S COMMENTS: ____

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

DISTRIBUTOR TYPE INJECTION PUMP
UNIT III

PRACTICAL TEST
JOB SHEET #3 — INSTALL A DISTRIBUTOR TYPE PUMP ON AN ENGINE

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ______________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:		YES	NO
1.	Checked out proper tools and materials.		
2.	Removed timing window.		
3.	Set pump on number one.		
4.	Set engine on #1 compression stroke.		
5.	Greased drive shaft.		
6.	Slid pump into position.		
7.	Installed and tightened mounting nuts to proper torque.		
8.	Backed off engine ½ revolution.		
9.	Then rotated in direction of rotation and rechecked timing.		
10.	Corrected if necessary.		
11.	Repeated procedures 8 & 9 if corrections were made.		
12.	Checked in/put away tools and materials.		
13.	Cleaned the work area.		
14.	Used proper tools correctly.		
15.	Performed steps in a timely manner (____hrs. ____min. ____sec.)		
16.	Practiced safety rules throughout procedure.		
17.	Provided satisfactory responses to questions asked.		

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #3 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:	4	3	2	1
Distributor pump is properly installed.				

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

DISTRIBUTOR TYPE INJECTION PUMP
UNIT III

NAME ______________________ SCORE ____________________

TEST

1. Match the terms on the right with their correct definitions.

_____a. Ring; a part, structure, or marking resembling a ring

_____b. Operated or moved by liquid in motion

_____c. Oil passage that indexes with a port in a rotating head

_____d. Act of drawing back

_____e. Automatic device for controlling large amounts of power with small amounts of power as a piston moved by fluid under pressure

_____f. Complete path of fuel flow

_____g. Normally uses two or four plungers to distribute fuel to all cylinders

_____h. Provides retraction of delivery line pressure causing nozzle valve to return to its seat, preventing dribble of fuel into combustion chamber

_____i. Precision measurement of fuel delivery

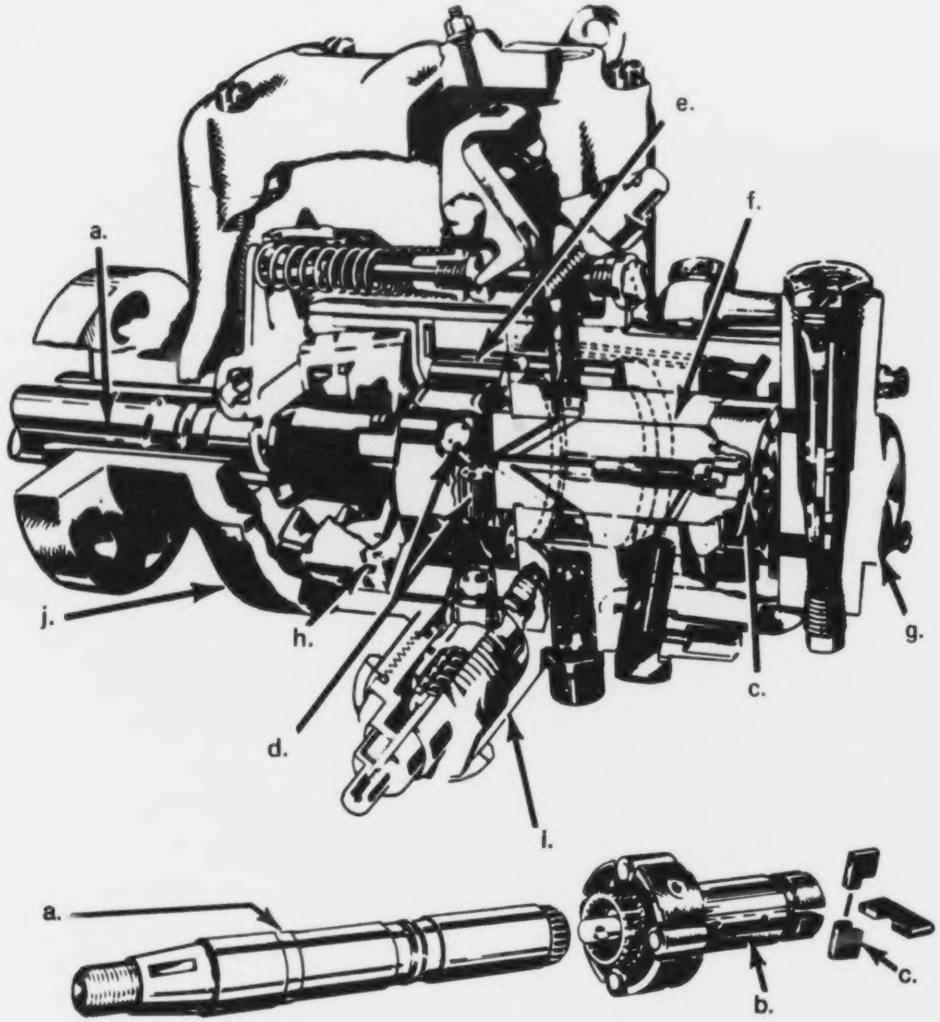
_____j. A speed-sensing device that employs centrifugal force and spring tension to govern the engine speed

_____k. Pressure measuring device

1. Aneroid
2. Annulus
3. Circuit
4. Delivery valve
5. Distributor type injection system
6. Governor
7. Hydraulic
8. Metering
9. Registry
10. Retraction
11. Servomechanism

TEST

2. Identify the main parts of a distributor type pump.


e.
f.
a.
j.
h.
g.
c.
d.
i.
a.
c.
b.

a. ______________________ b. ______________________

c. ______________________ d. ______________________

e. ______________________ f. ______________________

g. ______________________ h. ______________________

i. ______________________ j. ______________________

TEST

3. Name three rotating parts of a distributor type pump.

a. ____

b. ____

c. ____

4. Match the main parts of a distributor type pump on the right with their functions.

______a. Turns distributor rotor in the hydraulic head

______b. Rotation of rotor causes pumping action of plungers which discharge fuel when passages index with appropriate passages in the hydraulic head

______c. Draws fuel from supply tank through inlet strainer to pump

______d. Provide pressure to transfer fuel from rotor to hydraulic head to injection nozzles

______e. Actuates the pumping plungers

______f. Contains the metering valve and the bore in which the rotor revolves

______g. Houses the transfer pump pressure regulating valve and fuel strainer

______h. Regulates the speed by positive mechanical linkage to metering valve

______i. Hydraulic servomechanism powered by oil pressure from the transfer pump which advances injection timing

______j. Contains all component parts

1. Automatic speed advance
2. Distributor rotor
3. Drive shaft
4. End plate
5. Governor
6. Housing
7. Hydraulic head
8. Internal cam ring
9. Pumping plungers
10. Transfer pump

5. Select true statements concerning the principles of operation of a distributor type pump by placing an "X" beside each statement that is true.

______a. Drive shaft engages the distributor rotor in the hydraulic head.

______b. Plungers are actuated toward each other simultaneously by the internal cam-ring to pump fuel.

______c. As rotor revolves inside hydraulic head, the discharge passage in the rotor indexes with appropriate passage in the hydraulic head to lead to the injector nozzles.

TEST

6. Complete statements concerning the flow of fuel during a complete pump cycle on a distributor type pump by circling the correct word(s).

   a. Fuel is drawn from the supply tank into the pump through the inlet strainer by the vane type fuel (**transfer pump, filter**).

   b. Transfer pump pressure forces fuel through drilled passages in the (**rotor, hydraulic head**) into the annulus.

   c. Transfer pump pressure (**increases, decreases**) with speed.

   d. Fuel flows around the annulus to top of sleeve and through connecting passages to (**metering valve, pressure regulating valve**).

   e. Metering valve regulates the flow of fuel into the (**annulus, charging ring**) which incorporates the charging ports.

   f. As the rotor revolves, the twin inlet passages register with two charging ports in the hydraulic head allowing (**fuel, motor oil**) to flow into the pumping cylinders.

   g. With further rotation, the inlet passages move out of registry and the (**single, dual**) discharge port is opened.

   h. The rollers contact the cam lobes forcing the plungers (**together, outward**).

   i. Fuel trapped between the plungers is then delivered through delivery valve to the (**tank, nozzle**).

7. Select true statements concerning charging cycle operation by placing an "X" beside each statement that is true.

   _____a. When the rotor revolves, the angled inlet passages in the rotor line up with the charging ports of the charging ring.

   _____b. Pressurized fuel from the transfer pump, controlled by the opening of the metering valve, flows to the pumping cylinders forcing all plungers together.

   _____c. The plungers move outward enough to supply the correct quantity of fuel for the engine load.

8. Complete the following list of statements concerning discharge cycle operation by inserting the words that best complete each statement.

   a. As the rotor continues to revolve, the angled inlet passages no longer line up with the ____________ ____________.

   b. Fuel is momentarily trapped until the rotor discharge passage lines up with one of the ____________ ____________.

TEST

c. The rollers contact the cam lobes and are forced together.

d. Fuel is then forced through the axial passage of the rotor, then to the ____________ ____________.

e. Delivery of the fuel will continue until the rotors pass the ____________ ____________ on the cam.

f. The fuel pressure in the axial passage is then reduced to a point where the injection nozzle closes.

9. Select true statements concerning delivery valve operation by placing an "X" beside each statement that is true.

_____a. Controlled line retraction is the most important job of the delivery valve; this is accomplished by reducing injection line pressure to a point lower than that of the nozzle closing pressure.

_____b. The delivery valve is located in a drilled passageway in the center of the rotor.

_____c. There is a delivery valve for every cylinder.

_____d. As injection begins, fuel pressure moves the delivery valve off its shoulder to allow the volume of its displacement to enter the cavity that houses the delivery valve spring.

_____e. This displaces a similar volume of fuel in the spring cavity before delivery starts through the valve ports.

_____f. At the end of injection, the pressure on the plunger side of the delivery valve is increased, allowing the cam rollers to fall into the retraction step of the cam lobes.

_____g. As the valve moves back, the fuel is removed from the spring cavity and flows through the rotor intake port; then, as the rotor revolves, it is trapped.

10. Select true statements concerning return fuel oil circuit functions by placing an "X" beside each statement that is true.

_____a. Transfer pump pressure is discharged into a cavity in the hydraulic head.

_____b. The lower part of this cavity has a vent passage connected to it.

_____c. Should air enter the transfer pump, it will be bled off and returned to the fuel tank.

TEST

11. Name three functions of an end plate.

    a. ______________________________

    b. ______________________________

    c. ______________________________

12. Complete the following list of optional features of a distributor type pump by inserting the missing features.

    a. Viscosity compensator

    b. ______________________________

    c. Automatic load advance

    d. ______________________________

    e. ______________________________

    f. Electric shut-off

    g. Aneroid

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

13. Demonstrate the ability to:

    a. Remove a distributor type pump from an engine. (Job Sheet #1)

    b. Bench test a distributor type pump. (Job Sheet #2)

    c. Install a distributor type pump on an engine. (Job Sheet #3)

DISTRIBUTOR TYPE INJECTION PUMP
UNIT III

ANSWERS TO TEST

1.
   - a. 2
   - b. 7
   - c. 9
   - d. 10
   - e. 11
   - f. 3
   - g. 5
   - h. 4
   - i. 8
   - j. 6
   - k. 1

2.
   - a. Drive shaft
   - b. Distributor rotor
   - c. Transfer pump
   - d. Pumping plungers
   - e. Internal cam-ring
   - f. Annulus in hydraulic head
   - g. End plate
   - h. Governor
   - i. Automatic advance
   - j. Housing

3.
   - a. Drive shaft
   - b. Distributor rotor
   - c. Transfer pump blades

4.
   - a. 3
   - b. 2
   - c. 10
   - d. 9
   - e. 8
   - f. 7
   - g. 4
   - h. 5
   - i. 1
   - j. 6

5. a, b, c

6.
   - a. Transfer pump
   - b. Hydraulic head
   - c. Increases
   - d. Metering valve
   - e. Charging ring
   - f. Fuel
   - g. Single
   - h. Together
   - i. Nozzle

7. a, c

8.
   - a. Charging ports
   - b. Head outlets
   - d. Injection line
   - e. High point

ANSWERS TO TEST

9. a, b, d, e

10. a, c

11. a. Provides fuel inlet passages and houses pressure regulating valve
    b. Covers the fuel transfer pump
    c. Absorbs end thrust of drive and governor

12. b. Centrifugal governor
    d. Automatic speed advance
    e. Torque control

13. Performance skills evaluated to the satisfaction of the instructor

UNIT INJECTORS
UNIT IV

UNIT OBJECTIVE

After completion of this unit, the student should be able to disassemble, assemble, test, and install a unit injector. Competencies will be demonstrated by completing the job sheets and the unit tests with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to unit injectors with the correct definitions.
2. Match the parts of a unit injector with the correct part names.
3. List functions of a unit injector.
4. Arrange in order the steps in fuel flow through the unit injector fuel system.
5. Identify the sealing parts of a unit injector.
6. Distinguish between no injection and full injection.
7. Demonstrate the ability to:
    a. Locate a faulty injector. (Job Sheet #1)
    b. Remove unit injector from engine. (Job Sheet #2)
    c. Disassemble a unit injector. (Job Sheet #3)
    d. Assemble a unit injector. (Job Sheet #4)
    e. Test a unit injector. (Job Sheet #5)
    f. Install a unit injector. (Job Sheet #6)

UNIT INJECTORS
UNIT IV

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in this unit of instruction.

(NOTE: This activity should be completed prior to the teaching of this unit.)

B. Make transparencies from the transparency masters included with this unit.

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information sheet.

F. Discuss information sheet.

(NOTE: Use the transparencies to enhance the information as needed.)

G. Provide students with job sheets.

H. Discuss and demonstrate the procedures outlined in the job sheets.

I. Integrate the following activities throughout the teaching of this unit:

  1. Demonstrate lapping and cleaning procedures.
  2. Obtain a chart on unit injectors.
  3. Show a film or film strip on unit injectors.
  4. Take a field trip to a Detroit Diesel dealer.
  5. Show film strips.
  6. Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas for improvement.

J. Give test.

K. Evaluate test.

L. Reteach if necessary.

REFERENCE USED IN DEVELOPING THIS UNIT

Service Manual, Detroit Diesel Engines, Series 53. Detroit, MI: Detroit Diesel Allison, 1980.

SUGGESTED SUPPLEMENTAL RESOURCES

Text

Dagel, John F. New York: *Diesel Engine Repair. John Wiley and Sons, 1982.*

Filmstrip

Servicing the GM Detroit Diesel Engine Fuel Injector. Tarrytown, NY: Prentice-Hall Media.

(NOTE: To order this filmstrip, write to Prentice-Hall Media, Serv Code YL, 150 White Plains Road, Tarrytown, NY 10591.

UNIT INJECTORS
UNIT IV

INFORMATION SHEET

I. **Terms and definitions**

A. Bushing — Serves as a barrel for the plunger on unit injector

B. Control rack and gear — Rack and pinion gear arrangement on unit injector

C. Helix — Spiraled recess machined into plunger

D. Port — Drilled passage in bushing

E. Spray valve — Serves as a nozzle to atomize fuel sprayed into combustion chamber

F. Unit injector — Injection pump, injector, and spray valve form a single unit (Transparencies 1 and 2)

(NOTE: One unit is provided for each cylinder.)

II. **Parts of a unit injector** (Transparencies 1 and 2)

A. Follower

B. Follower spring

C. Stop pin

D. Filter cap

E. Plunger

F. Gasket

G. Injector body

H. Filter

I. Gear

J. Gear retainer

K. Dowel

L. Control rack

M. Seal

INFORMATION SHEET

N. Bushing

O. Spill deflector

P. Lower port

Q. Upper port

R. Check valve

S. Check valve cage

T. Valve spring

U. Spring cage

V. Spring seat

W. Needle valve

X. Body unit

Y. Spray tip

Z. Identification tag

III. **Functions of a unit injector**

A. Creates a high fuel pressure

(NOTE: This is needed for efficient injection.)

B. Meters required amount of fuel

C. Atomizes fuel

D. Times injection

E. Injects fuel

(NOTE: Fuel and air are mixed in the combustion chamber.)

IV. **Fuel flow through the unit injector fuel system** (Transparency 3)

A. Enters injector through a filter cap and filter

B. Passes through drilled passages and ports into supply chamber

(NOTE: The supply chamber is that area between the plunger bushing and the spill deflector, in addition to that area under the injector plunger within the bushing.)

INFORMATION SHEET

C. Pump pressure forces fuel through small orifices in spray tip

D. Atomized into combustion chamber

V. **Sealing parts of a unit injector** (Transparency 2)

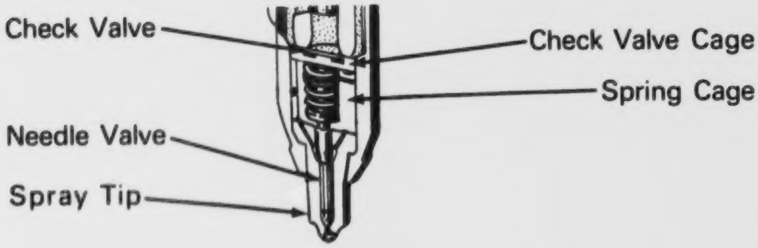
A. Spray tip

B. Needle valve

C. Spring cage

D. Check valve cage

E. Check valve



VI. **Differences between no injection and full injection** (Transparency 4)

(NOTE: Changing the position of the helices by rotating the plunger increases or decreases the amount of fuel injected into the cylinder.)

A. No injection

1. Control rack out

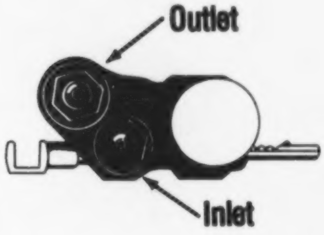
2. Upper port is not closed by helix

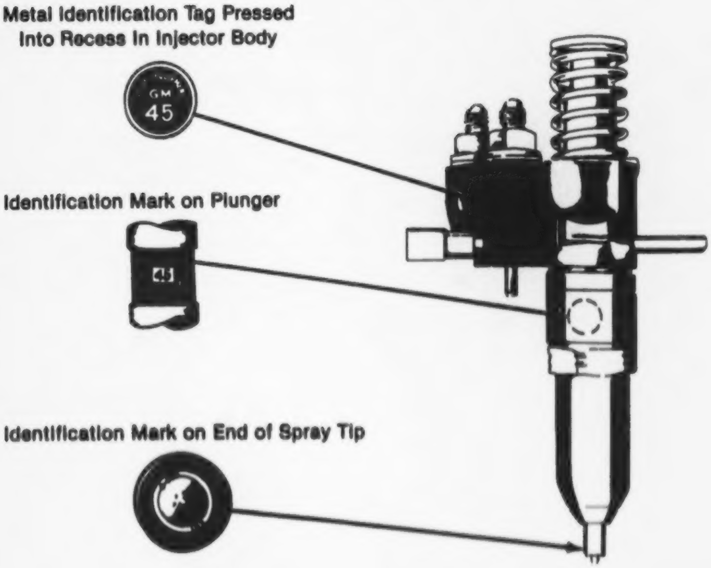
B. Full injection

1. Control rack in

2. Upper port is closed and lower port is closed by helix

Unit Injector


Outlet
Inlet


Metal Identification Tag Pressed Into Recess in Injector Body
GM
45
Identification Mark on Plunger
Identification Mark on End of Spray Tip

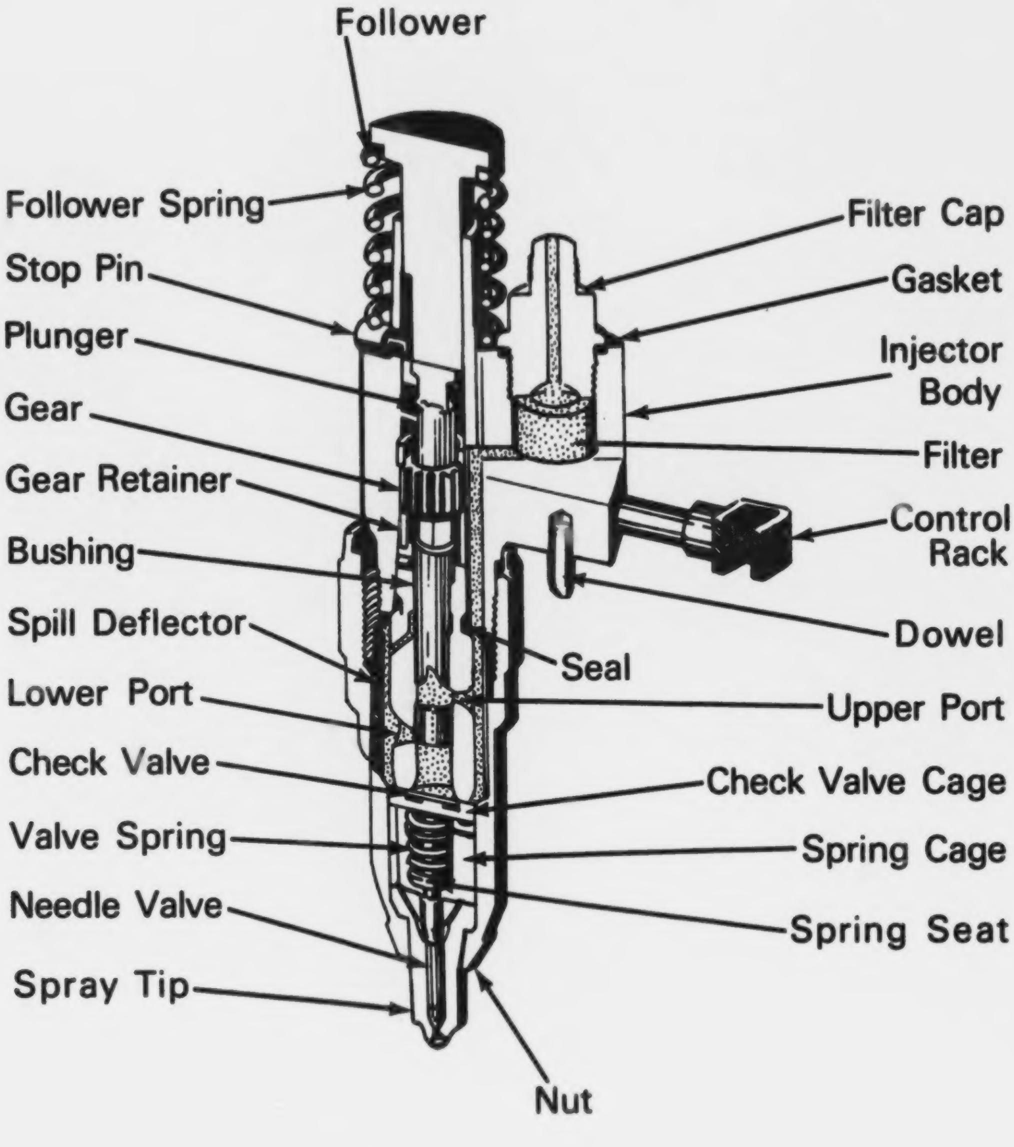
INJECTOR	SPRAY TIP*	PLUNGER
N35	6—.006 —165A	N35
L40	8—.0055—165A	4L
N40	6—.006 —165A	4N
N45	6—.006 —165A	45N
N50	6—.006 —165A	5N
C40	6—.006 —165A	4C
C45	6—.006 —165A	45C
C50	6—.006 —165A	5C
5A55	8—.0060—165A	5A55
5A60	8—.0060—165A	6N
N55	8—.0055—165A	55N
N60	8—.0055—165A	6N
N65	8—.006 —165A	65N
N70	7—.006 —165	7N
M60	7—.006 —165	5N
M70	7—.0060—165A	M70

*First numeral indicates number of spray holes, followed by size of holes and angle formed by spray from holes.

Courtesy of Detroit Diesel Corporation

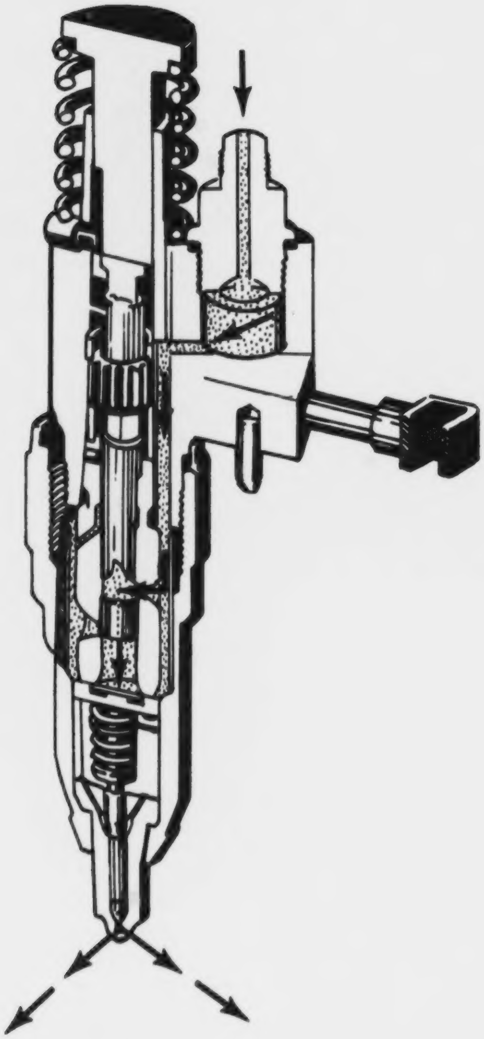
Parts of a Unit Injector

Needle Valve


Follower
Follower Spring
Stop Pin
Plunger
Gear
Gear Retainer
Bushing
Spill Deflector
Lower Port
Check Valve
Valve Spring
Needle Valve
Spray Tip
Nut
Filter Cap
Gasket
Injector Body
Filter
Control Rack
Dowel
Seal
Upper Port
Check Valve Cage
Spring Cage
Spring Seat

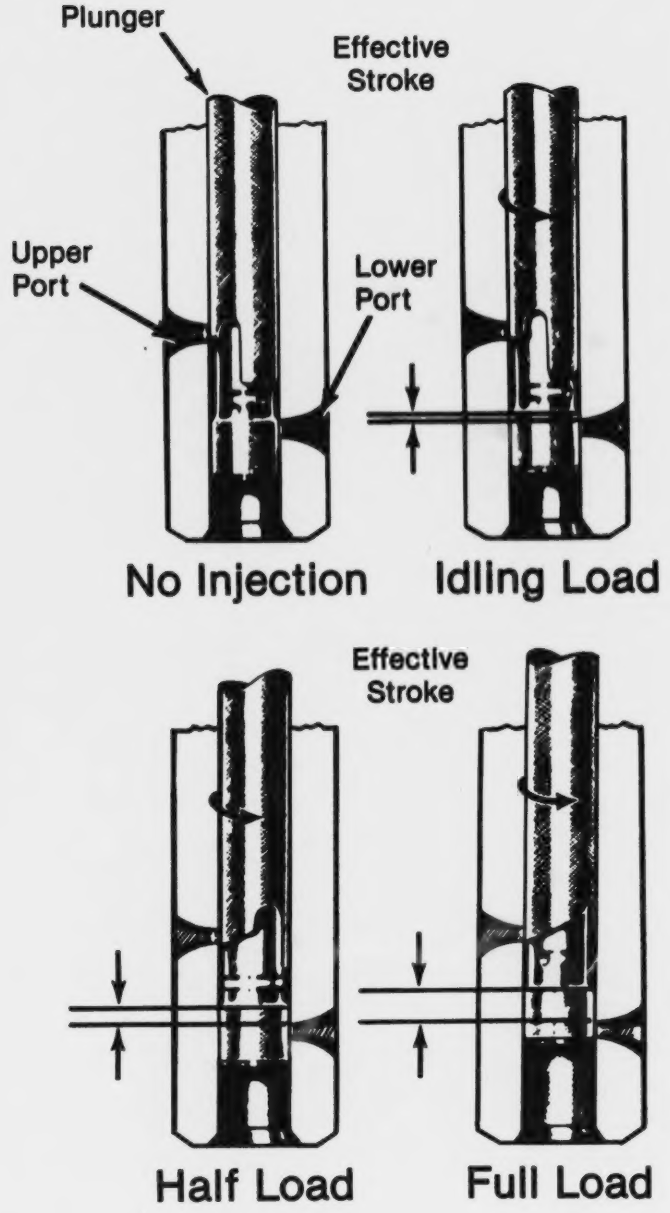
Fuel Flow Through Unit Injector

Needle Valve



Courtesy of Detroit Diesel Corporation

Plunger Positions


Plunger
Effective Stroke
Upper Port
Lower Port
No Injection
Idling Load
Effective Stroke
Half Load
Full Load

Various plunger positions from no-load to full-load of unit injector.

UNIT INJECTORS
UNIT IV

JOB SHEET #1 — LOCATE A FAULTY INJECTOR

A. Tools and materials

1. Engine with needle valve injector
2. Appropriate service manual
3. Hand tool set
4. Heel bar
5. Shop towels (lint-free)
6. Safety glasses

B. Procedure

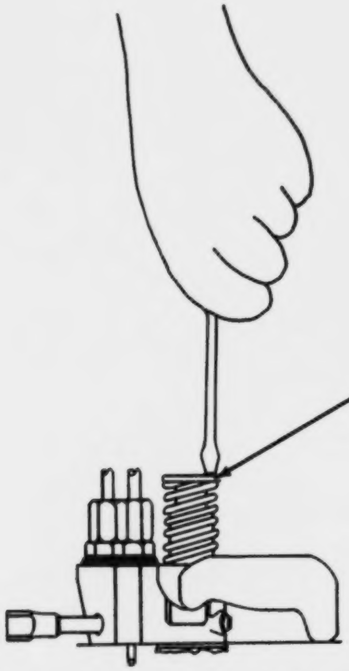
(CAUTION: Follow all shop safety procedures.)

1. Start engine and bring to operating temperature.
2. Stop engine and remove valve cover(s).
3. Check valve clearance.
4. Start engine.

JOB SHEET #1

5. Hold injector follower down with a screwdriver to prevent operation of the injector. (Figure 1)

FIGURE 1



Courtesy of Detroit Diesel Corporation

(NOTE: If the cylinder is misfiring, there will be no noticeable difference in sound or RPM of the engine; if the cylinder is firing, there will be a noticeable difference in sound and RPM.)

6. Check all cylinders to determine the faulty cylinder(s).

7. Install new injector(s).

(NOTE: Smooth operation of the engine indicates the old injector is faulty. No change indicates other problems.)

UNIT INJECTORS
UNIT IV

JOB SHEET #2 — REMOVE UNIT INJECTOR FROM ENGINE

A. Tools and materials

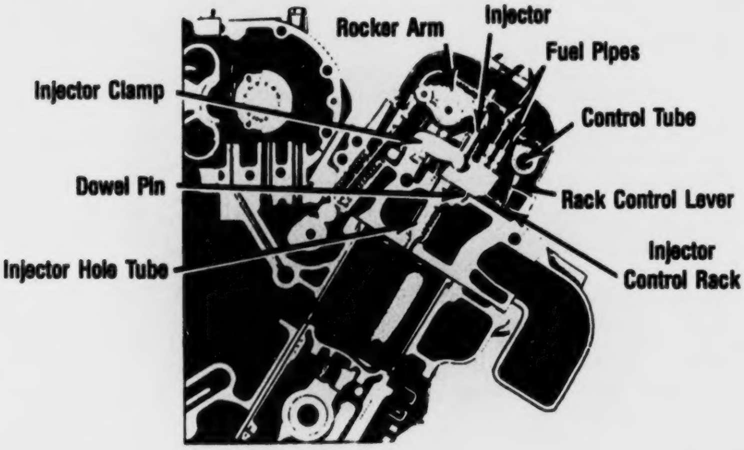
1. Needle valve fuel injector
2. Appropriate service manual
3. Hand tool set
4. Heel bar
5. Shop towels (lint-free)
6. Safety glasses

B. Procedure

(CAUTION: Follow all shop safety procedures.)

1. Remove the valve rocker cover(s).
2. Remove the fuel pipes from both the injector and the fuel connectors. (Figure 1)

FIGURE 1


Rocker Arm
Injector
Fuel Pipes
Injector Clamp
Control Tube
Dowel Pin
Rack Control Lever
Injector Hole Tube
Injector Control Rack

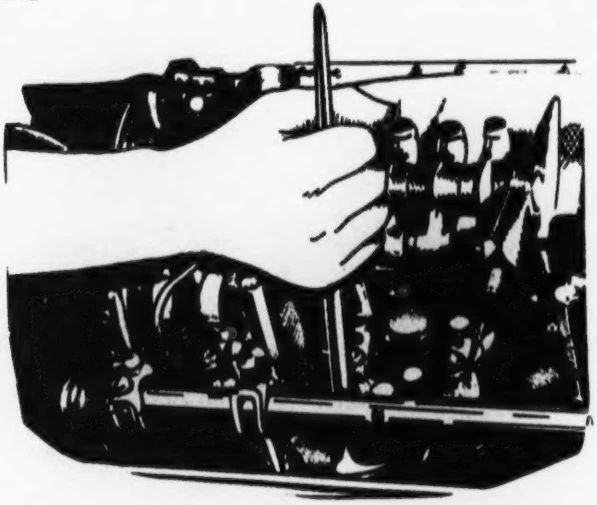
(NOTE: Immediately after removal of the fuel pipes from an injector, cover the filter caps with shipping caps to prevent dirt from entering the injector. Also protect the fuel pipes and fuel connectors from entry of dirt or foreign material.)

JOB SHEET #2

3. Rotate the engine to bring the outer ends of the push rods of the injector and valve rocker arms in line horizontally.

4. Remove the two rocker shaft bracket bolts, and swing the rocker arms away from the injector and valves. (Figure 2)

FIGURE 2



5. Remove the injector clamp bolt, special washer, and clamp.

6. Loosen the inner and outer adjusting screws on the injector rack control lever, and slide the lever away from the injector.

7. Lift the injector from its seat in the cylinder head. (Figure 2)

   (CAUTION: Pry on injector body only.)

8. Cover the injector hole in the cylinder head to keep foreign material out.

9. Clean the exterior of the injector with clean fuel oil, and dry it with compressed air.

UNIT INJECTORS
UNIT IV

JOB SHEET #3 — DISASSEMBLE A UNIT INJECTOR

A. Tools and materials

1. Needle valve fuel injector
2. Appropriate service manual

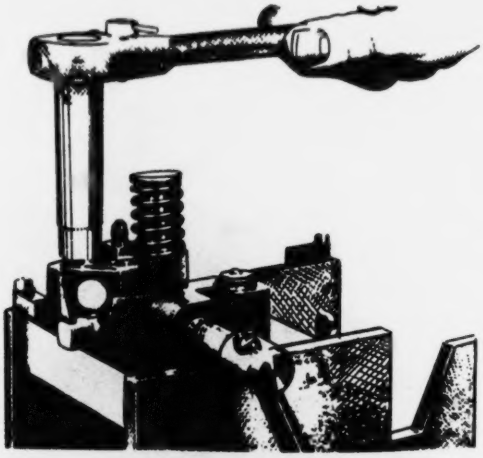
   (NOTE: Normally, in industry, unit injectors are pretested before disassembly.)
3. Injector nut socket wrench
4. Injector spray tip driver
5. Injector vise and rack freeness tester
6. Hand tool set
7. Shop towels (lint-free)
8. Safety glasses

B. Procedure

(CAUTION: Follow all shop safety procedures.)

1. Support the injector upright in injector vise and rack freeness tester, and remove the filter caps, springs, filters, and gaskets. (Figure 1)

FIGURE 1



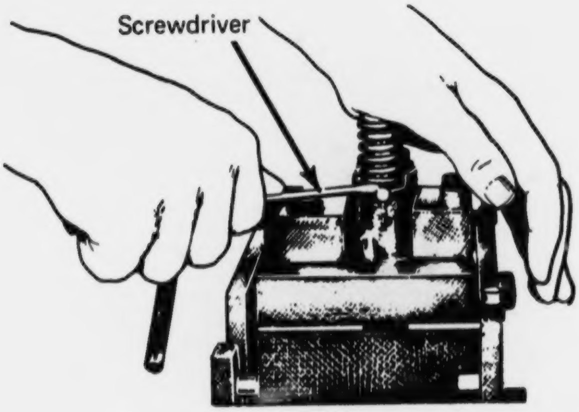
(NOTE: Whenever a fuel injector is disassembled, discard the filters and gaskets, and replace with new filters and gaskets.)

(CAUTION: Clean injector before removal and handle with care.)

JOB SHEET #3

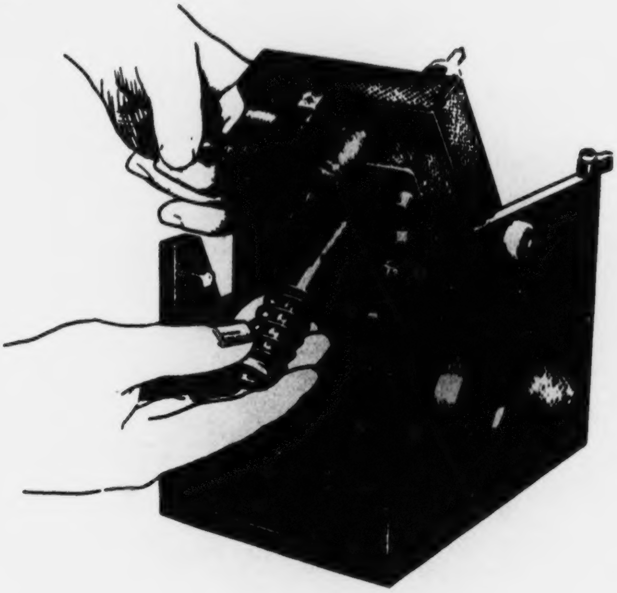
2. Compress the follower spring, and raise the spring above the stop pin with a screwdriver; withdraw the pin, and allow the spring to rise gradually. (Figure 2)

FIGURE 2



3. Remove the plunger follower, plunger, and spring as an assembly. (Figure 3)

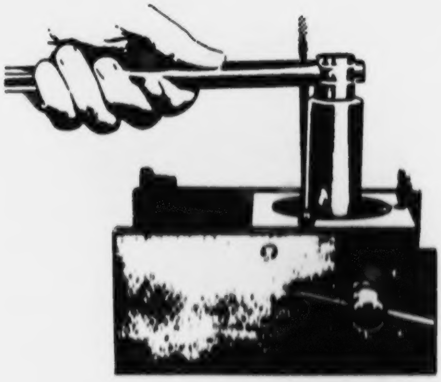
FIGURE 3



JOB SHEET #3

4. Invert the fixture, and using injector nut socket wrench, loosen the nut on the injector body. (Figure 4)

   FIGURE 4



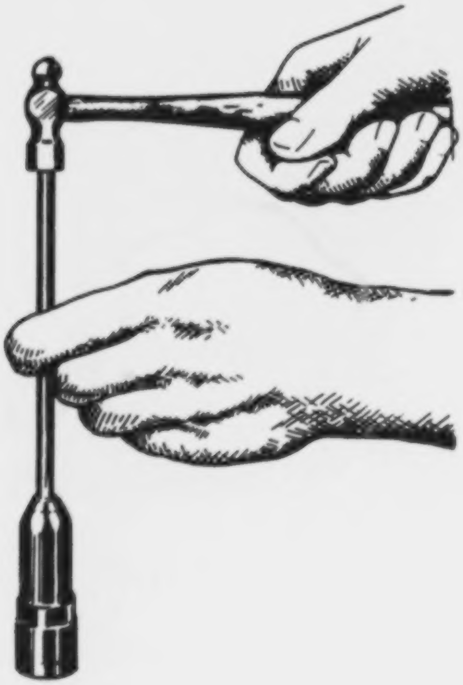
5. Lift the injector nut straight up, being careful not to dislodge the spray tip and valve parts.

6. Remove the spray tip and valve parts from the bushing, and place them in a clean receptacle until ready for assembly.

   (NOTE: When an injector has been in use for some time, the spray tip, even though clean on the outside, may not be pushed readily from the nut with the fingers. In this event, support the nut on a wood block and drive the tip down through the nut, using the injector spray tip driver. See Figure 5.)

JOB SHEET #3

FIGURE 5

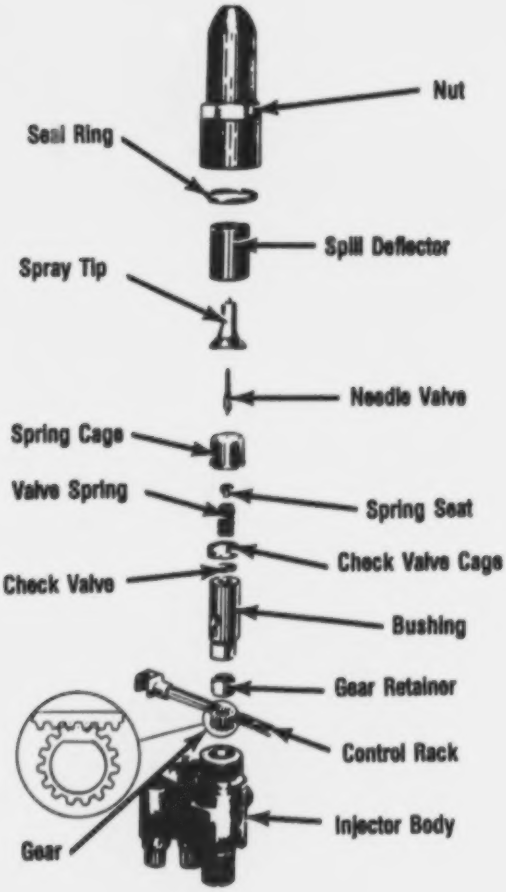


(NOTE: The injector spray tip driver is a special tool.)

JOB SHEET #3

7. Remove the spill deflector and the seal ring from the injector nut. (Figure 6)

FIGURE 6


Nut
Seal Ring
Spill Deflector
Spray Tip
Needle Valve
Spring Cage
Valve Spring
Spring Seat
Check Valve Cage
Check Valve
Bushing
Gear Retainer
Control Rack
Injector Body
Gear

8. Remove the plunger bushing, gear retainer, and gear from the injector body.

9. Withdraw the injector control rack from the injector body.

UNIT INJECTORS
UNIT IV

JOB SHEET #4 — ASSEMBLE A UNIT INJECTOR

A. Tools and materials

1. Needle valve fuel injector
2. Appropriate service manual
3. Injector vise and rack freeness tester
4. Injector nut socket wrench
5. Deep well socket, $^9/_{16}$"
6. Torque wrench
7. Hand tool set
8. Fuel oil or calibrating oil
9. Shop towels (lint-free)
10. Safety glasses
11. Clean bench

JOB SHEET #4

B. Procedure

(CAUTION: ollow all shop safety procedures.)

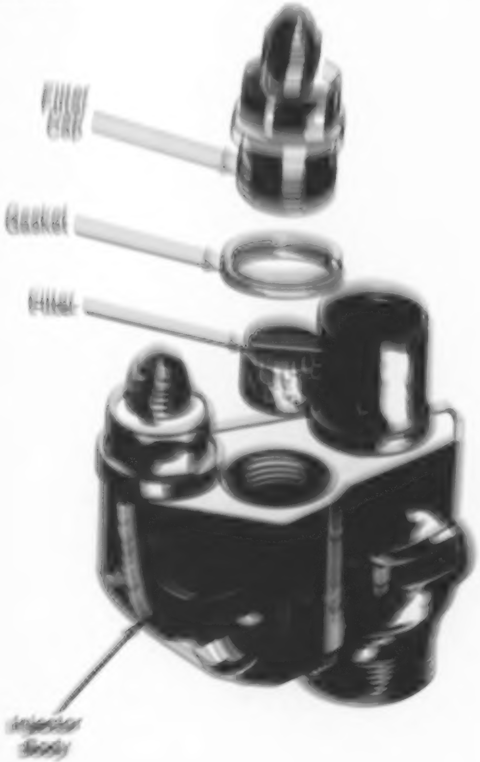
1. Asse ble injector filters.

   (NOT : Use an extremely clean bench to work on and to place parts on when asser bling an injector. Also, be sure all injector parts, both new and used, are clean Flush parts in fuel oil or calibrating oil during assembly.)

   a. Study relative position of injector parts. (Figures 1 and 2)

   b. Put filter on inlet side.

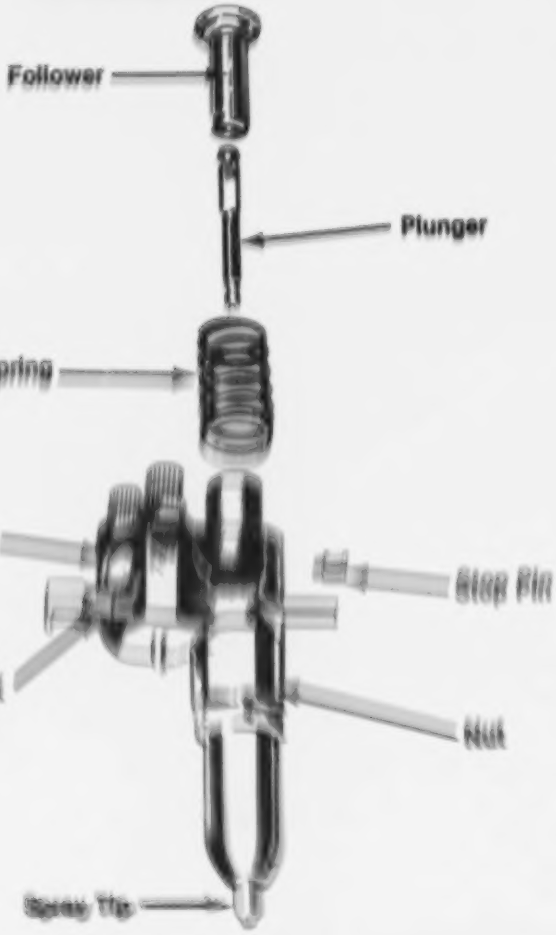
FIGURE 1



Courtesy of Detroit Diesel Corporation

JOB SHEET #4

FIGURE 2


Follower
Plunger
Follower Spring
Injector Body
Stop Pin
Control Rack
Nut
Spray Tip

c. Hold the injector body right side up, and place a new filter (slot in the filter up or toward the filter cap) in each of the fuel cavities in the top of the injector body. (Figure 1)

d. Place a spring on top of each filter (if an early design filter cap is used) and a new gasket on each filter cap.

e. Lubricate the threads, and install the filter caps.

f. Use a 9/16" deep socket wrench and tighten the filter caps to specified torque.

g. Purge the filters after installation by directing compressed air or fuel through the filter caps.

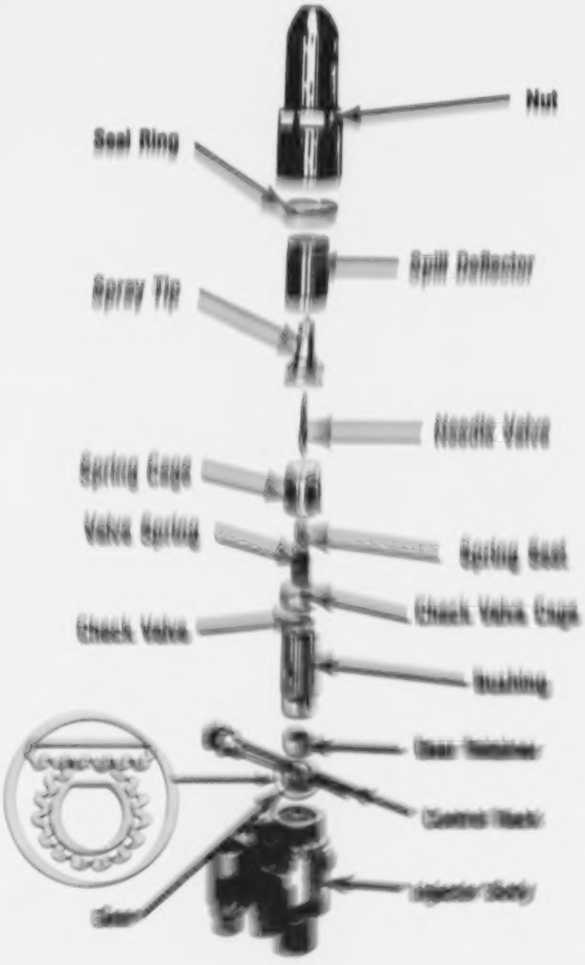
h. Install clean shipping caps on the filter caps to prevent dirt from entering the injector.

JOB SHEET #4

2. Assemble rack and gear.

   (NOTE: Observe the drill spot marks (timing marks) on the control rack and gear. See Figure 3.)

   FIGURE 3


Nut
Seal Ring
Spill Deflector
Spray Tip
Needle Valve
Spring Cage
Valve Spring
Spring Seat
Check Valve Cage
Check Valve
Bushing
Gear Retainer
Control Rack
Injector Body
Gear

   a. Hold the injector body, bottom end up, and slide the rack through the hole in the body.

   b. Look into the bore for the rack teeth, then move the rack until you can see the drill marks, and hold the rack in this position.

   c. Place the gear in the injector body so that the marked tooth is engaged between the two marked teeth on the rack.

JOB SHEET #4

d. Place the gear retainer on top of the gear.

e. Align the locating pin in the bushing with the slot in the injector body, then slide the end of the bushing into place.

3. Assemble check valve cage and related parts.

(NOTE: Make sure the check valve cage and related parts have been lapped and cleaned. See Figure 3.)

a. Support the injector body, bottom end up, in the injector vise and freeness tester.

b. Place a new seal ring on the shoulder of the body, then slide the spill deflector over the barrel of the bushing.

c. Place the check valve and check valve cage on the bushing.

d. Place assembled spring cage on check valve cage.

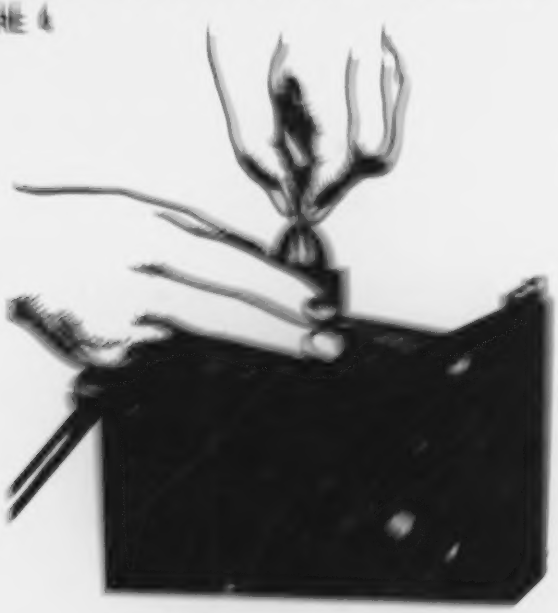
e. Lower the valve cage over this assembly so that the spring seat seats in the cage, and place the valve cage assembly on the valve seat.

f. Locate the needle valve centrally on the cage, and place the spray tip over the needle valve and against the spring cage.

g. Lubricate the threads in the injector nut, and carefully thread the nut onto the injector body by hand.

(NOTE: Rotate the spray tip between your thumb and first finger while threading the nut on the injector body. See Figure 4.)

FIGURE 4



JOB SHEET #4

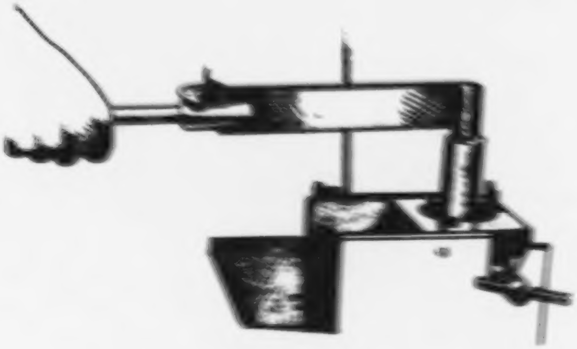
h. Tighten the nut as tight as possible by hand.

(NOTE: At this point there should be sufficient force on the spray tip to make it impossible to turn with your fingers.)

i. Use injector nut socket wrench and torque wrench to tighten the injector nut to specified torque. (Figure 5)

(CAUTION: Do not exceed the specified torque; otherwise, the nut may be stretched and result in improper sealing of the lapped surfaces in a subsequent injector overhaul. Avoid cross threading the nut during installation.)

FIGURE 5



4. Assemble plunger and follower.

   a. Slide the head of the plunger into the follower. (Figure 2)

   b. Invert the injector in the assembly fixture (filter cap end up), and push the rack all the way in; then place the follower spring on the injector body.

   c. Place the stop pin on the injector body so that the follower spring rests on the narrow flange of the stop pin.

   d. Align the slot in the follower with the stop pin hole in the injector body.

   e. Align the flat side of the plunger with the slot in the follower.

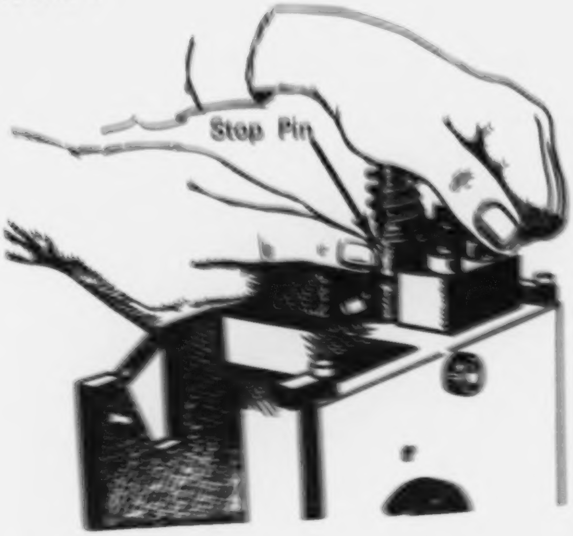
   f. Insert the free end of the plunger into the injector body.

JOB SHEET #4

g. Press down on the follower and at the same time press the stop pin into position. (Figure 6)

(NOTE: When in place, the spring will hold the stop pin in position.)

FIGURE 6



h. Retest the injector after assembly.

UNIT INJECTORS
UNIT IV

JOB SHEET #5 — TEST A UNIT INJECTOR

A. Tools and materials

1. Needle valve fuel injector
2. Appropriate service manual
3. Hand tool set
4. Injector vise and rack freeness tester
5. Injector tester
6. Comparator injector tester or appropriate calibrator injector tester
7. Shop towels (lint-free)
8. Safety glasses

B. Procedure

(CAUTION: Follow all shop safety procedures.)

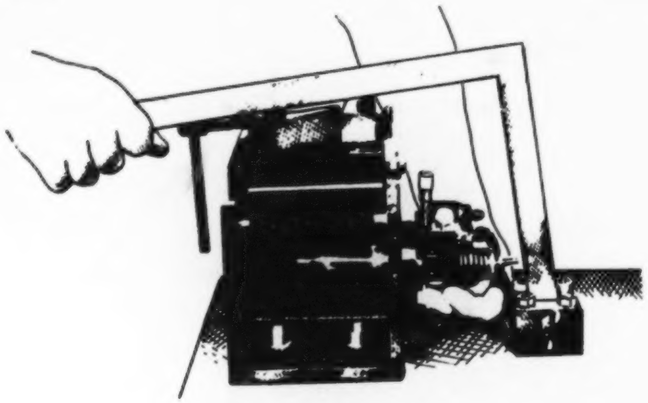
(NOTE: Identify each injector, and record the pressure drop and fuel output as indicated by the following tests.)

1. Test injector control rack and plunger movement.
    a. Place the injector in the injector vise and rack freeness tester.

JOB SHEET #5

b. Place the handle on top of the injector follower. (Figure 1)

FIGURE 1



(NOTE: If necessary, adjust the contact screw in the handle to insure the contact screw is at the center of the follower when the follower spring is compressed.)

c. Hold the injector control rack in the no-fuel position; push the handle down, and depress the follower to the bottom of its stroke.

d. Release the pressure on the handle very slowly while moving the control rack up and down until the follower reaches the top of its travel. (Figure 1)

(NOTE: If the rack does not fall freely, loosen the injector nut, turn the tip, then retighten the nut. Loosen and retighten the nut a couple of times if necessary. Generally this will free the rack. Then, if the rack isn't free, change the injector nut. In some cases it may be necessary to disassemble the injector to eliminate the cause of the misaligned parts.)

2. Test injector valve opening pressure.

(NOTE: The purpose of the valve opening pressure test is to determine the pressure at which the valve opens and injection begins.)

a. Place the injector in the tester with the dowel on the underside of the injector located in the proper slot of the adaptor plate.

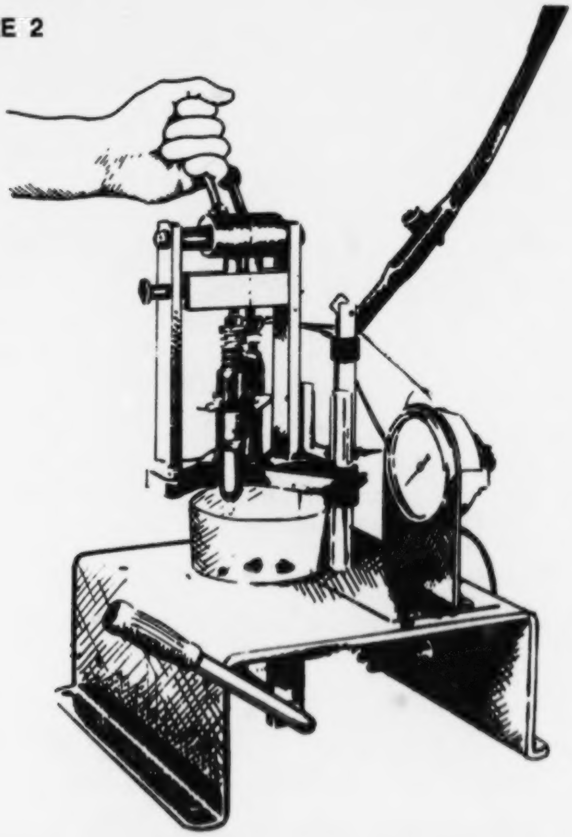
JOB SHEET #5

b. Position the injector handle support to the proper height. (Figure 2)

(NOTE: When testing an injector just removed from an engine, the flow of fuel through the injector on the tester should be the same as in the engine. Connections on the test head of the tester may be changed to obtain the correct direction of flow.)

(CAUTION: Always place the injector in the proper position in relation to the spray deflector before it is tested to prevent the fuel spray from penetrating the skin. Fuel oil which enters the blood stream can cause a serious infection.)

FIGURE 2

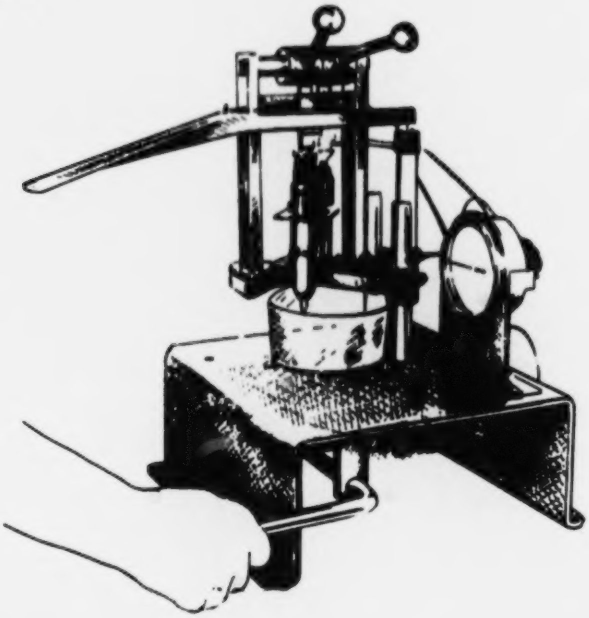


c. Close the inlet clamp and operate the pump handle until all of the air is purged from the injector tester and the injector; then, close the outlet clamp.

JOB SHEET #5

d. With the injector rack in the full-fuel position, pump the handle of the injector tester with smooth, even strokes, and record the injector valve opening pressure indicated when the injector sprays fuel. (Figure 3)

FIGURE 3



(NOTE: The specified valve opening pressure is 2300 to 3300 psi. If the pressure is not within the above range, refer to manufacturer's trouble-shooting chart.)

3. Perform injector valve holding pressure test.

(NOTE: The injector valve holding pressure test will determine whether the various lapped surfaces in the injector are sealing properly.)

a. Operate the pump handle to bring the pressure up to a point just below the injector valve opening pressure (approximately 450 psi).

b. Close the fuel shut-off valve and note the pressure drop.

(NOTE: The time for a pressure drop from 450 psi to 250 psi should not be less than 40 seconds. If the pressure drop is less than 40 seconds, follow procedures 1 through 3.)

1) Dry the injector thoroughly with compressed air.

2) Open the tester fuel valve and operate the pump handle to maintain the test pressure.

JOB SHEET #5

3) Correct malfunctions as appropriate.

a) A leak around the spray tip or seal ring usually is caused by a loose injector nut, a damaged seal ring, or hardened surface on the injector nut or spray tip.

b) A leak at the filter cap indicates a loose filter cap or damaged filter cap gasket.

c) A "dribble" at the spray tip orifices indicates a leaking valve assembly due to a damaged surface or dirt; leakage at the tip will cause pre-ignition in the engine.

(NOTE: A drop or two of fuel at the spray tip is only an indication of the fuel trapped in the spray tip at the beginning of the test and is not detrimental as long as the pressure drop specified is not less than 40 seconds.)

4. Perform injector high pressure test.

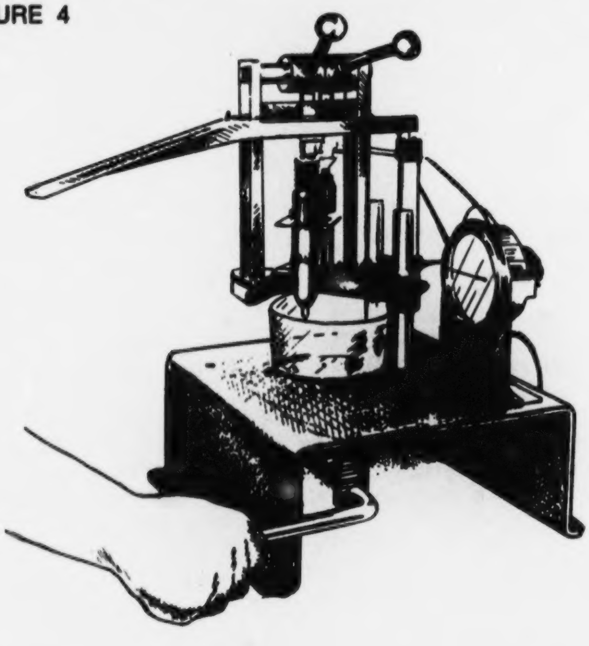
(NOTE: This test is performed to discover any fuel leaks at the injector filter cap gaskets, body plugs and nut seal ring which did not appear during the valve holding pressure test. The high pressure test also indicates whether or not the plunger and bushing clearance is satisfactory.)

a. Thoroughly dry the injector with compressed air.

b. Check the fuel connections for leaks; if leaks have occurred, tighten the connections, dry the injector, and recheck.

c. With the injector rack in the full-fuel position and the injector tester handle locked in position by means of the handle lock, operate the pump handle to build up and maintain the pressure. (Figure 4)

FIGURE 4



JOB SHEET #5

d. Use the adjusting screw in the injector tester handle to depress the injector plunger just far enough to close both ports in the injector bushing.

(NOTE: The point at which both ports are closed may be easily determined by the fact that the injector spray will decrease appreciably and a rise in pressure will occur. At this time, the condition of the plunger and bushing may be established. If there is excessive clearance between the plunger and bushing, pressure beyond the normal valve opening pressure cannot be obtained. Replacement of the plunger and bushing assembly is then required.)

e. Pump up the injector tester and maintain a pressure of 1600 to 2000 psi by actuating the pump handle; then, inspect for leaks at the injector filter cap gaskets, body plugs, and injector nut seal ring.

(NOTE: If any of these conditions exist, refer to manufacturer's troubleshooting chart. It is normal for fuel to seep out around the rack due to high pressure fuel being applied to a normally low pressure area in the injector assembly. However, fuel droplets at the rack indicate excessive leakage.)

(CAUTION: Do not permit the pressure in the injector tester to equal or exceed the capacity of the pressure gauge.)

5. Test spray pattern.

a. Open the fuel shut-off valve, place the injector rack in the full-fuel position, and operate the injector several times in succession by operating the tester handle at approximately 40 strokes per minute.

b. Observe the spray pattern to see that all spray orifices are open and injecting evenly.

(NOTE: The beginning and ending of injection should be sharp, and the fuel injected should be finely atomized. See Figure 4.)

c. If all of the spray tip orifices are not open and injecting evenly, clean the orifices in the spray tip.

(CAUTION: To prevent damage to the pressure gauge, do not exceed 100 psi during this test.)

6. Test fuel output.

(NOTE: The injector fuel output test can be performed in either the comparator J 7041 or the calibrator J 22410. See Figures 5 and 6.)

(CAUTION: When injectors are removed from an engine for fuel output testing and, if satisfactory, reinstalled without disassembly, extreme care should be taken to avoid reversing the fuel flow. When the fuel flow is reversed, dirt trapped by the filter is back-flushed into the injector components.)

JOB SHEET #5

(NOTE: Before removing an injector from the engine, observe the direction of the fuel flow. To avoid reversing the fuel flow when checking injector fuel output, use the appropriate adaptor. The position of the fuel flow pipes on the comparator depends on the adaptor being used and the direction of fuel flow through the injector. (Figure 5) The position of the braided fuel inlet tube and the plastic fuel outlet tube on the calibrator depends on the adaptor being used and the direction of fuel flow through the injector. See Figure 6.)

FIGURE 5

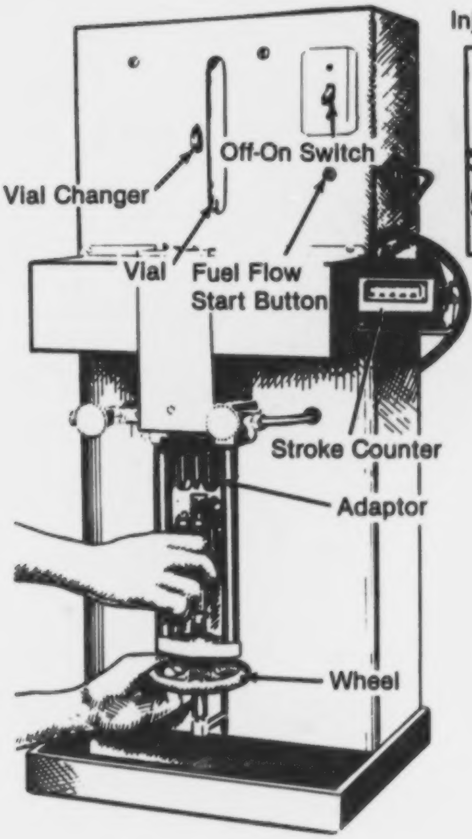
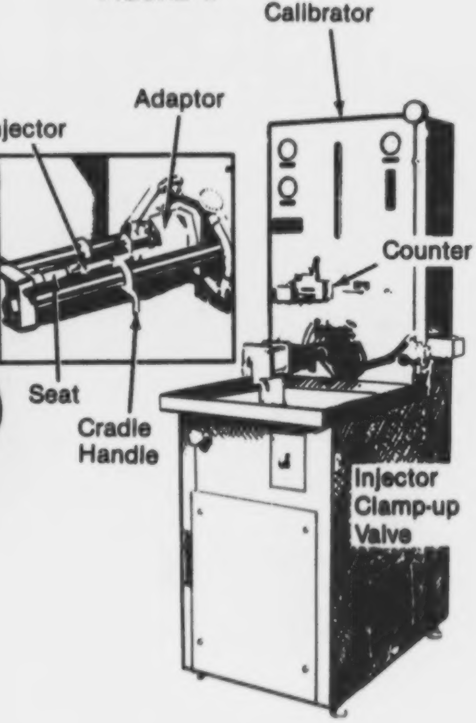

Off-On Switch
Vial Changer
Vial
Fuel Flow Start Button
Stroke Counter
Adaptor
Wheel

FIGURE 6


Calibrator
Adaptor
Injector
Counter
Seat
Cradle Handle
Injector Clamp-up Valve

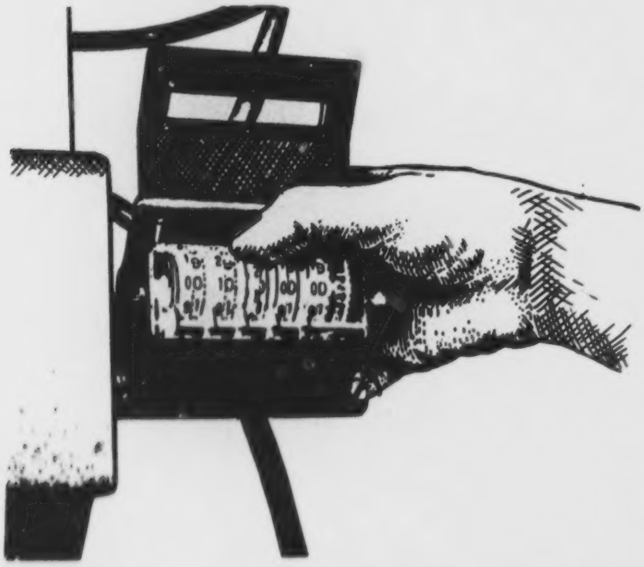
JOB SHEET #5

a. Check fuel output using appropriate comparator. (Figure 5)

1) Place the injector in the comparator, and tighten the hand wheel to clamp the injector and adaptor in position.

(NOTE: Make sure the counter on the comparator is preset to 1000 strokes. If, for any reason, this setting has been altered, raise the cover, and reset the counter to 1000 strokes by pulling the selector wheel to be changed to the right and rotating it to its proper setting. Then release the wheel and close the cover. Refer to the comparator instruction booklet for further information. See Figure 7.)

FIGURE 7



(NOTE: When installing a low clamp body injector in the comparator, position the injector in the adaptor at approximately a 45° angle, rather than straight into the adaptor; then, bring it into a vertical position and secure it in place.)

2) Pull the injector rack out to the no-fuel position.

3) Start the comparator by turning on the switch.

4) After the comparator has started, push the injector rack into the full-fuel position.

5) Let the injector run for approximately 30 seconds to purge the air that may be in the system.

JOB SHEET #5

6) After 30 seconds, press the fuel flow start button.

(NOTE: This will start the flow of fuel into the vial. The comparator will automatically stop the flow of fuel after 1000 strokes.)

7) After the fuel stops flowing into the vial, pull the injector rack out to the no-fuel position.

8) Turn the comparator off and reset the counter.

9) Observe the reading on the vial, and refer to Figure 8 to determine if the injector fuel output falls within its specified limits.

(NOTE: If the quantity of fuel in the vial does not fall within the specified limits, refer to manufacturer's troubleshooting chart for cause and remedy.)

FIGURE 8

Injector	Calibrator J 22410	
	Min.	Max.
N35	36	41
L40	41	46
N40	42	47
N45	47	52
N50	50	55
C40	42	47
C45	47	52
C50	50	55
5A50	53	58
5A55	56	61
5A60	63	68
[illegible]	53	58
[illegible]	57	62
[illegible]	64	69
[illegible]	64	69
[illegible]	71	76
[illegible]	80	85
[illegible]	72	77

Courtesy of Detroit Diesel Corporation

c. Check fuel output using appropriate calibrator. (Figure 8)

1) Place the cam shift index wheel and fuel flow lever in their respective positions.

2) Turn on the test fuel oil heater switch and preheat the test oil to 95°-105°F.

3) Place the proper injector adaptor between the tie rods, and engage it with the fuel block locating pin.

4) Slide the adaptor forward and up against the fuel block face.

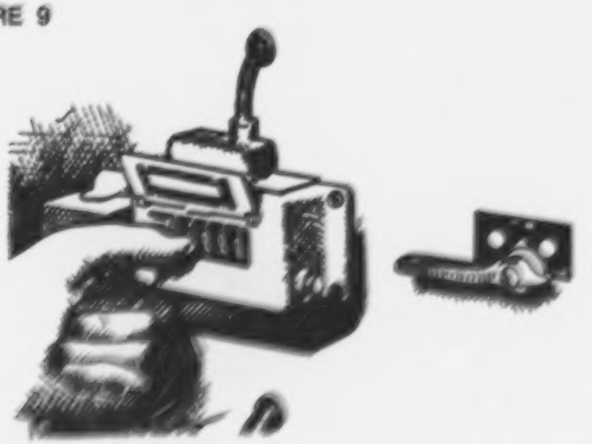
JOB SHEET #5

5) Place the injector seat into the permanent seat (position section in vertical position).

6) Clamp the injector into position by operating the air valve.

(NOTE: Make sure the counter on the calibrator is preset at 1000 strokes. (Figure 9) If for any reason this setting has been altered, reset the counter to 1000 strokes by twisting the cover release button to the left, and hold the reset lever in the full up position while setting the numbered wheels. Close the cover. Refer to the calibrator instruction booklet for further information .)

FIGURE 9



7) Pull the injector rack out to the no-fuel position.

8) Turn on the main power control circuit switch.

9) Start the calibrator by turning on the motor starter switch.

(NOTE: The low oil pressure warning buzzer will sound briefly until the lubricating oil reaches the proper pressure.)

10) After the calibrator has started, set the injector rack into the full-fuel position.

(NOTE: Allow the injector to operate for approximately 30 seconds to purge the air that may be in the system.)

11) After the air is purged, press the fuel flow start button (red).

(NOTE: This will start the flow of fuel into the vial. The fuel flow to the vial will automatically stop after 1000 strokes.)

JOB SHEET #5

12) Shut the calibrator off (the calibrator will stop in less time at full-fuel).

13) Observe the vial reading and refer to Figure 6 to determine whether the injector fuel output falls within the specified limits.

(NOTE: If the quantity of fuel in the vial does not fall within the specified limits, refer to manufacturer's troubleshooting chart for the cause and remedy. The comparator or the calibrator may be used to check and select a set of injectors which will inject the same amount of fuel in each cylinder at a given throttle setting, thus resulting in a smooth-running, well balanced engine. An injector which passes all of the above tests may be put back into service. An injector which fails to pass one or more of the tests must be rebuilt and checked on the comparator or the calibrator. Any injector which is disassembled and rebuilt must be tested again before being placed in service.)

UNIT INJECTORS
UNIT IV

JOB SHEET #5 — INSTALL A UNIT INJECTOR

A. Tools and materials

1. Needle valve fuel injector

2. Appropriate service manual

3. Hand tool set

4. Injector tube bevel reamer

5. Fuel pipe socket

6. Torque wrench

7. White grease

8. Shop towels (lint-free)

9. Safety glasses

JOB SHEET #6

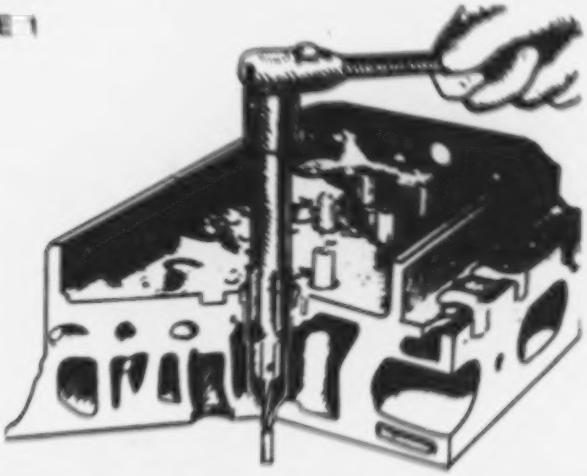
B. Procedure

(CAUTION: Follow all shop safety procedures.)

(NOTE: Before installing an injector in an engine, remove the carbon deposits from the beveled seat of the injector tube in the cylinder head. This will assure correct alignment of the injector and prevent any undue stress from being exerted against the spray tip.)

1. Use injector tube bevel reamer to clean the carbon from the injector tube. (Figure 1)

FIGURE 1



(CAUTION: Exercise care to remove ONLY the carbon so that the proper clearance between the injector body and the cylinder head is maintained. Pack the flutes of the reamer with grease to retain the carbon removed from the tube.)

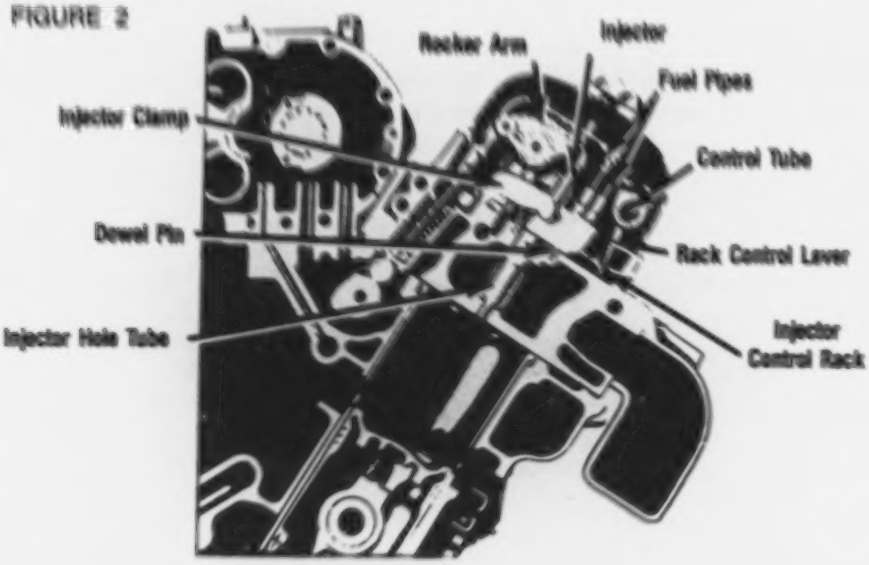
(NOTE: Be sure the fuel injector is filled with fuel oil. If necessary, add clean fuel oil at the inlet filter cap until it runs out of the outlet filter cap.)

JOB SHEET #6

2. Insert the injector into the injector tube with the dowel in the injector body registering with the locating hole in the cylinder head. (Figure 2)

   (NOTE: Level injectors to prevent bent push rods.)

   FIGURE 2


Rocker Arm
Injector
Fuel Pipes
Injector Clamp
Control Tube
Dowel Pin
Rack Control Lever
Injector Hole Tube
Injector
Control Rack

3. Slide the rack control lever over so that it registers with the injector rack.

4. Install the injector clamp, special washer (with curved side toward injector clamp) and bolt, and tighten the bolt to specified torque, making sure that the clamp does not interfere with the injector follower spring or the exhaust valve springs.

   (NOTE: Check the injector control rack for free movement. Excess torque can cause the control rack to stick or bind.)

5. Move the rocker arm assembly into position, and secure the rocker arm brackets to the cylinder head by tightening the bolts to the torque specified in service manual.

   (CAUTION: On four valve cylinder heads, there is a possibility of damaging the exhaust valves if the exhaust valve bridges are not resting on the ends of the exhaust valves when tightening the rocket shaft bracket bolts. Therefore, note the position of the exhaust valve bridges before, during, and after tightening the rocker shaft bolts.)

JOB SHEET #6

6. Remove the shipping caps; then, install the fuel pipes and connect them to the injector and the fuel connectors, using fuel pipe socket to tighten the connections to specified torque.

   (NOTE: A specified fuel pipe socket may be needed; refer to appropriate service manual.)

   (CAUTION: Do not bend the fuel pipes and do not exceed the specified torque. Excessive tightening will twist or fracture the flared end of the fuel line and result in leaks. Lubricating oil diluted by fuel oil can cause serious damage to the engine bearings.)

7. Refer to service manual for final adjustments and tune-up procedures.

8. Pressure test fuel system for leaks before running the engine. Check at 60 to 80 psi.

   (NOTE: Refer to shop manual.)

UNIT INJECTORS
UNIT IV

PRACTICAL TEST
JOB SHEET #1 — LOCATE A FAULTY INJECTOR

STUDENT'S NAME ______________________ DATE __________

EVALUATOR'S NAME ______________________ ATTEMPT NO. _____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Started engine.	______	______
3. Removed valve cover.	______	______
4. Checked valve clearance.	______	______
5. Started engine.	______	______
6. Checked injectors.	______	______
7. Checked in/put away tools and materials.	______	______
8. Cleaned the work area.	______	______
9. Used proper tools correctly.	______	______
10. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
11. Practiced safety rules throughout procedure.	______	______
12. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #1 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:	4	3	2	1
Located faulty injector				

EVALUATOR'S COMMENTS: ____

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

UNIT INJECTORS
UNIT IV

PRACTICAL TEST
JOB SHEET #2 — REMOVE UNIT INJECTOR FROM ENGINE

STUDENT'S NAME ______________________ DATE __________

EVALUATOR'S NAME ______________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Removed rocker cover(s).	______	______
3. Removed fuel pipes.	______	______
4. Rotated engine.	______	______
5. Removed bolt swing back rockers.	______	______
6. Removed injector bolt and clamp.	______	______
7. Lifted injector from head.	______	______
8. Covered injector hole.	______	______
9. Checked in/put away tools and materials.	______	______
10. Cleaned the work area.	______	______
11. Used proper tools correctly.	______	______
12. Performed steps in a timely manner (____hrs. ____min. ____sec.)	______	______
13. Practiced safety rules throughout procedure.	______	______
14. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #2 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:	4	3	2	1
Removed injector.				

EVALUATOR'S COMMENTS: ____________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

UNIT INJECTORS
UNIT IV

PRACTICAL TEST
JOB SHEET #3 — DISASSEMBLE A UNIT INJECTOR

STUDENT'S NAME ______________________ DATE __________

EVALUATOR'S NAME ______________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Removed filter caps.	______	______
3. Removed follower and plunger.	______	______
4. Removed nut.	______	______
5. Removed the spray tip and valve parts.	______	______
6. Placed tip and parts into a clean receptacle.	______	______
7. Checked in/put away tools and materials.	______	______
8. Cleaned the work area.	______	______
9. Used proper tools correctly.	______	______
10. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
11. Practiced safety rules throughout procedure.	______	______
12. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #3 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:	4	3	2	1
Unit injector is properly disassembled.				

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

UNIT INJECTORS
UNIT IV

PRACTICAL TEST
JOB SHEET #4 — ASSEMBLE A UNIT INJECTOR

STUDENT'S NAME ____________________ DATE __________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	____	____
2. Installed injector filters and torqued.	____	____
3. Purged the filters.	____	____
4. Installed and timed the rack.	____	____
5. Replaced seal ring on the shoulder.	____	____
6. Installed check valve cage, spring cage, spray tip.	____	____
7. Installed nut and torqued.	____	____
8. Installed plunger and stop pin.	____	____
9. Retested the injector.	____	____
10. Checked in/put away tools and materials.	____	____
11. Cleaned the work area.	____	____
12. Used proper tools correctly.	____	____
13. Performed steps in a timely manner (___hrs. ___min. ___sec.)	____	____
14. Practiced safety rules throughout procedure.	____	____
15. Provided satisfactory responses to questions asked.	____	____

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #4 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:	4	3	2	1
Injector is properly assembled and retested.				

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

UNIT INJECTORS
UNIT IV

PRACTICAL TEST
JOB SHEET #5 — TEST A UNIT INJECTOR

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ______________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Checked control rack movement.	______	______
3. Checked opening pressure.	______	______
4. Checked valve holding pressure test.	______	______
5. Checked injector high pressure test.	______	______
6. Checked spray pattern.	______	______
7. Checked injection comparator.	______	______
8. Checked in/put away tools and materials.	______	______
9. Cleaned the work area.	______	______
10. Used proper tools correctly.	______	______
11. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
12. Practiced safety rules throughout procedure.	______	______
13. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #5 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:				
	4	3	2	1
Injector output is correct.				
	4	3	2	1
No leaks				

EVALUATOR'S COMMENTS: ____

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

UNIT INJECTORS
UNIT IV

PRACTICAL TEST
JOB SHEET #6 — INSTALL A UNIT INJECTOR

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ____________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Cleaned carbon from injector tube.	______	______
3. Inserted injector on dowel.	______	______
4. Installed injector clamp.	______	______
5. Installed rocker arm assembly.	______	______
6. Installed fuel pipes.	______	______
7. Made final adjustment.	______	______
8. Checked in/put away tools and materials.	______	______
9. Cleaned the work area.	______	______
10. Used proper tools correctly.	______	______
11. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
12. Practiced safety rules throughout procedure.	______	______
13. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #6 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:				
	4	3	2	1
Injector is properly installed and adjusted.				

EVALUATOR'S COMMENTS: ____

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

UNIT INJECTORS
UNIT IV

NAME ______________________ SCORE ____________________

TEST

1. Match the terms on the right with the correct definitions.

_____a. Serves as a nozzle to atomize fuel sprayed into combustion chamber

_____b. Spiraled recess machined into plunger

_____c. Drilled passage in bushing

_____d. Rack and pinion gear arrangement on unit injector

_____e. Serves as a barrel for the plunger on unit injector

_____f. Injection pump, injector, and spray valve form a single unit

1. Bushing
2. Control rack and gear
3. Helix
4. Port
5. Spray valve
6. Unit injector
7. Valve cage

2. Match the parts of a unit injector on the right with the correct part names.

_____a. Follower

_____b. Plunger

_____c. Gear

_____d. Valve spring

_____e. Filter

_____f. Spray tip

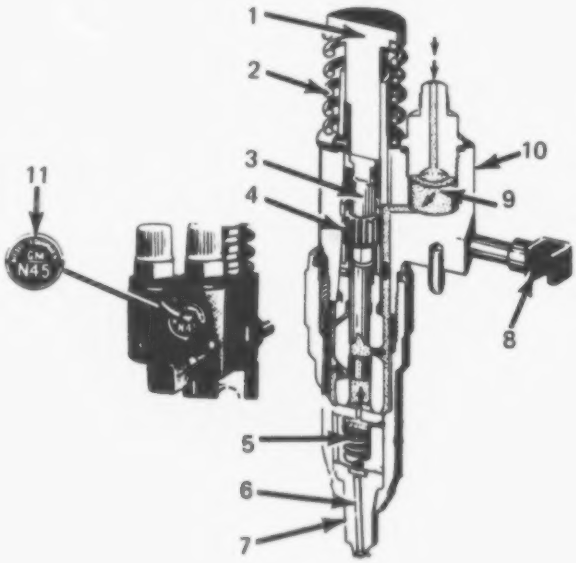
_____g. Control rack

_____h. Needle valve

_____i. Injector body

_____j. Follower spring

_____k. Identification tag



TEST

3. List three functions of a unit injector.

a. ______________________________

b. ______________________________

c. ______________________________

4. Arrange in order the steps in fuel flow through the unit injector fuel system by placing the correct sequence number beside each step.

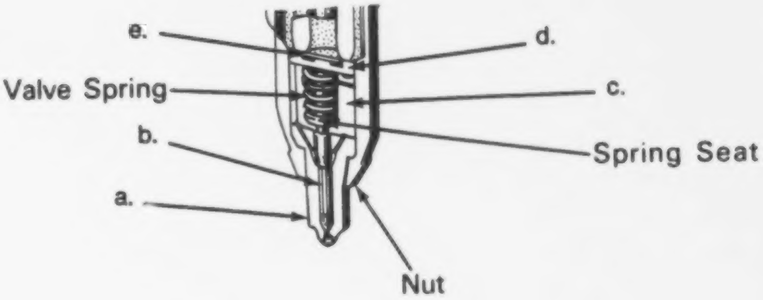
_____a. Passes through drilled passages and ports into supply chamber

_____b. Atomized into combustion chamber

_____c. Pump pressure forces fuel through small orifices in spray tip

_____d. Enters injector through a filter cap and filter

5. Identify the sealing parts of a unit injector.



a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

TEST

6. Distinguish between no injection and full injection by placing an "X" next to the descriptions of no injection.

_____a. Control rack out

_____b. Control rack in

_____c. Upper port is not closed by helix

_____d. Upper port is closed and lower port is closed by helix

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

7. Demonstrate the ability to:

   a. Locate a faulty injector. (Job Sheet #1)

   b. Remove unit injector from engine. (Job Sheet #2)

   c. Disassemble a unit injector. (Job Sheet #3)

   d. Assemble a unit injector. (Job Sheet #4)

   e. Test a unit injector. (Job Sheet #5)

   f. Install a unit injector. (Job Sheet #6)

UNIT INJECTORS
UNIT IV

ANSWERS TO TEST

1. a. 5
   b. 3
   c. 4
   d. 2
   e. 1
   f. 6

2. a. 1
   b. 3
   c. 4
   d. 5
   e. 9
   f. 7
   g. 8
   h. 6
   i. 10
   j. 2
   k. 11

3. Any three of the following:
   a. Creates a high fuel pressure
   b. Meters required amount of fuel
   c. Atomizes the fuel
   d. Times injection
   e. Injects fuel

4. a. 2
   b. 4
   c. 3
   d. 1

5. a. Spray tip
   b. Needle valve
   c. Spring cage
   d. Check valve cage
   e. Check valve

6. a, c

7. Performance skills evaluated to the satisfaction of the instructor

IN-LINE INJECTION PUMP
UNIT V

UNIT OBJECTIVE

After completion of this unit, the student should be able to remove, overhaul, and reassemble an in-line injection pump. Competencies will be demonstrated by completing the job sheets and the unit tests with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to an in-line injection pump with the correct definitions.
2. Match the main parts of an in-line pump with the correct names.
3. Arrange in order the steps in which fuel flows from supply tank to delivery.
4. State the purpose of a hand primer.
5. Select true statements concerning the purpose of a fuel transfer pump.
6. Select true statements concerning the operation of an injection pump.
7. Identify parts and design features of a pumping element.
8. Complete a list of statements concerning the operation of the control rack and sleeve.
9. State the purpose of a delivery valve.
10. Identify the plunger and rack positions.

OBJECTIVE SHEET

11. Identify typical tools used for overhauling an in-line injection pump.

12. Demonstrate the ability to:

    a. Remove an in-line pump. (Job Sheet #1)

    b. Overhaul an in-line pump. (Job Sheet #2)

    c. Clean and inspect in-line pump components. (Job Sheet #3)

    d. Reassemble an in-line pump. (Job Sheet #4)

    e. Reassemble the R.Q.V. governor. (Job Sheet #5)

    f. Bench test an in-line pump. (Job Sheet #6)

    g. Time an in-line pump. (Job Sheet #7)

IN-LINE INJECTION PUMP
UNIT V

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in this unit of instruction.

(NOTE: This activity should be completed prior to the teaching of this unit.)

B. Make transparencies from the transparency masters included with this unit.

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information sheet.

F. Discuss information sheet.

(NOTE: Use the transparencies to enhance the information as needed.)

G. Provide students with job sheets.

H. Discuss and demonstrate the procedures outlined in the job sheets.

I. Integrate the following activities throughout the teaching of this unit:

   1. Show Caterpillar slides on fuel flow timing and fuel injection pumps.
   2. Show actual components.
   3. Take field trip to pump shop if possible.
   4. Make a bulletin board with various in-line pumps.
   5. Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas for improvement.

J. Give test.

K. Evaluate test.

L. Reteach if necessary.

REFERENCES USED IN DEVELOPING THIS UNIT

A. Dagel, John F. *Diesel Engine Repair.* New York, NY: John Wiley and Sons, Inc., 1982.

B. *International Harvester Company Service Manual.* Westmont, IL: International Harvester Printing and Distribution Services.

C. *Mack Engine Manual.* King of Prussia, PA: Educational Communications, Inc.

SUGGESTED SUPPLEMENTAL RESOURCES

Texts

A. *Motor Heavy Truck Repair Manual,* 2nd ed., 1985
by Michael Kromida
555 West 57th Street
New York NY 10019

B. *Diesel Mechanics,* 2nd ed., 1983
by Erich Schulz
Gregg/McGraw-Hill
P.O. Box 996
Norcross, GA 30091
(404) 449-1837

Filmstrips

A. *Fuel Flow Timing* (¾" U-matic cassette)
SEVV 9091 Videotape 91

B. *Fuel Injection Pumps* (Slide presentation #43)
JE00 1308

(NOTE: These can be ordered from your nearest Caterpillar dealer.)

IN-LINE INJECTION PUMP
UNIT V

INFORMATION SHEET

I. **Terms and definitions**

   A. Aneroid — Device which limits fuel supply to engine, preventing excess smoke

   B. Annular groove — Machined recess forming a ring on pumping plunger

   C. Gallery — Long, narrow fuel or oil passage

   D. Governor — A speed-sensing device that employs centrifugal force and spring tension to govern engine speed

   E. Helix — Spiraled, machined recess on pumping plunger

   F. In-line injection pump — Uses an individual pump for each cylinder with pumps mounted in-line (Transparency 1)

   G. Transfer pump (supply pump) — Sends fuel at low pressure through filters to the injection pump

   H. Vertical slot — Located at right angles to the plane of the supporting surface

II. **Main parts of an in-line pump** (Transparency 2)

   A. Aneroid

   B. Individual pumping element

   C. Injection line

   D. Leak-off line

   E. Pump housing

   F. Hand primer

   G. Sediment bowl

   H. Fuel transfer pump

   I. Camshaft

   J. Control rack

   K. Governor

INFORMATION SHEET

III. **Fuel flow from supply tank to delivery** (Transparency 3)

A. Fuel is drawn from supply tank through primary filter by fuel transfer pump.

B. Tranfer pump forces fuel under low pressure through secondary filter to each injection pumping element.

C. Pumping element meters fuel at high pressure to each injection nozzle for delivery to combustion chamber.

IV. **Purpose of a hand primer** — Hand primer on fuel transfer pump can be operated by hand to pump fuel when bleeding the system. (Transparency 4)

V. **Purpose of a fuel transfer pump**

A. Draws fuel from supply tank through primary filter.

B. Assures fuel supply to injection pumping elements.

(NOTE: All fuel flows through a preliminary filter in the transfer pump sediment bowl.)

VI. **Operation of an injection pump** (Transparency 4)

A. Plunger type pump has engine driven camshaft rotating at half engine speed.

B. Roller cam followers, riding on cam lobes, operate the plungers to supply high pressure fuel through delivery valves to injection nozzles.

VII. **Parts and design features of a pumping element** (Transparency 5)

A. Spill ports

B. Plunger

C. Annular groove

D. Barrel

E. Helix

F. Vertical slot

VIII. **Operation of the control rack and sleeve** (Transparency 6)

A. Governor moves rack to regulate speed of engine.

B. The sleeve, rotated by the control rack, is fitted over the barrel and connects to the vanes on the plunger.

C. Plunger rotation opens or closes the helix which meters the quantity of fuel for delivery to cylinder.

INFORMATION SHEET

IX. **Purpose of a delivery valve** — The delivery valve creates a sudden pressure drop in the delivery line causing the injector nozzle valve to close instantly. (Transparency 6)

(NOTE: This effect prevents dribbling at the nozzle.)

X. **Plunger and rack positions** (Transparency 7)

A. No fuel delivery

B. Partial fuel delivery

C. Maximum fuel delivery

XI. **Typical tools used for overhauling an in-line injection pump** (Transparency 8)

(NOTE: The tool numbers listed below and on Transparency 8 refer to International Harvester tools only and will be used in upcoming job sheets.)

A. SE-2119 — Rack gauge holder

B. SE-2121 — Dial indicator (inch reading)

C. SE-2339 — Wrench, holding, drive flange

D. SE-2340 — Remover, governor flyweight damper

E. SE-2341 — Holder, tappet

F. SE-2342 — Gauge, camshaft protrusion

G. SE-2343 — Holder, dial indicator

H. SE-2344 — Remover and installer, camshaft cylindrical nut

I. SE-2345 — Remover and installer, tappet

J. SE-2346 — Remover and installer, barrel plunger

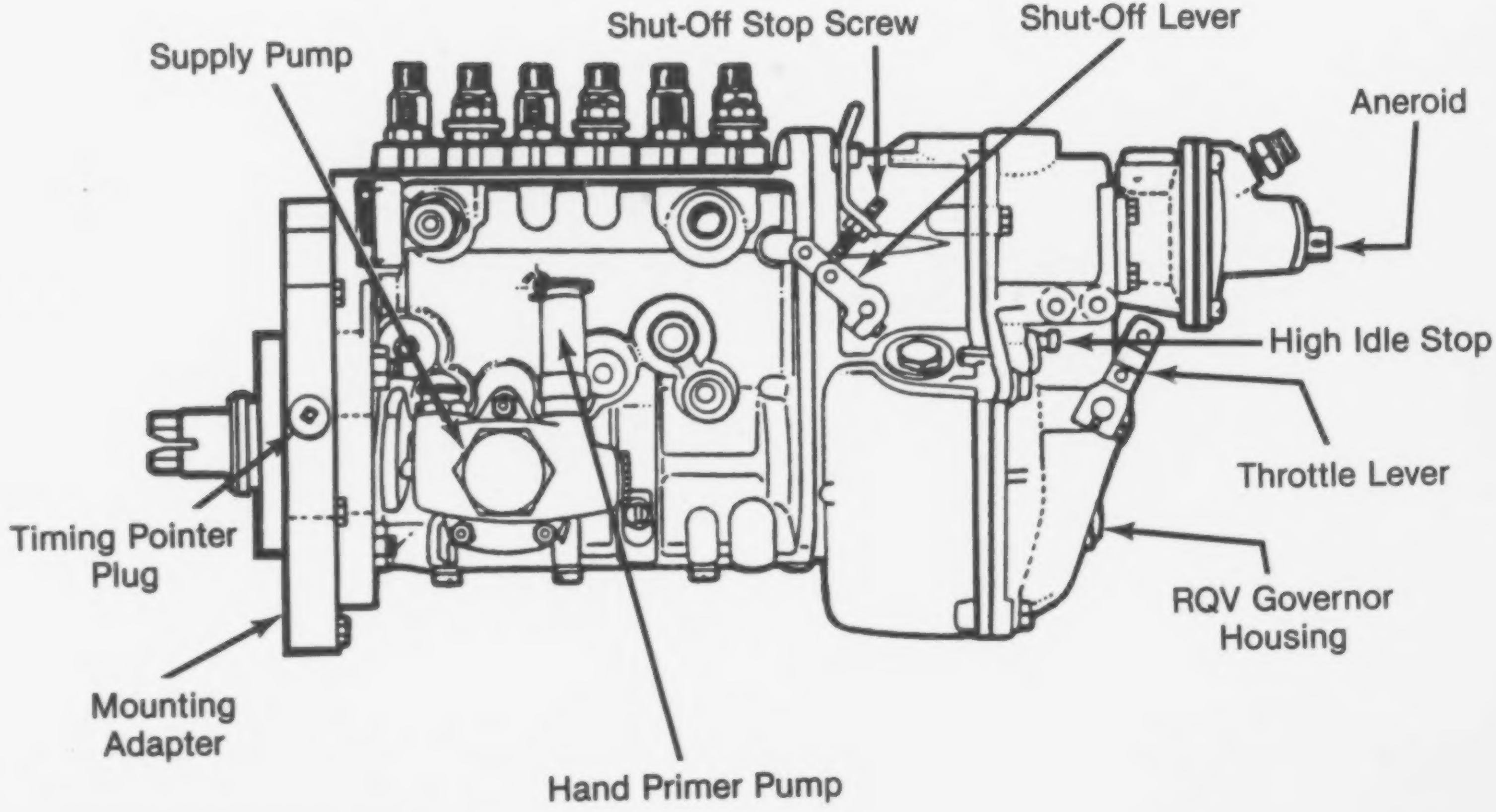
K. SE-2347 — Wrench, tappet adjusting

L. SE-2348 — Wrench, governor spring adjusting

M. SE-2349 — Remover and installer, governor spring and adjusting screw

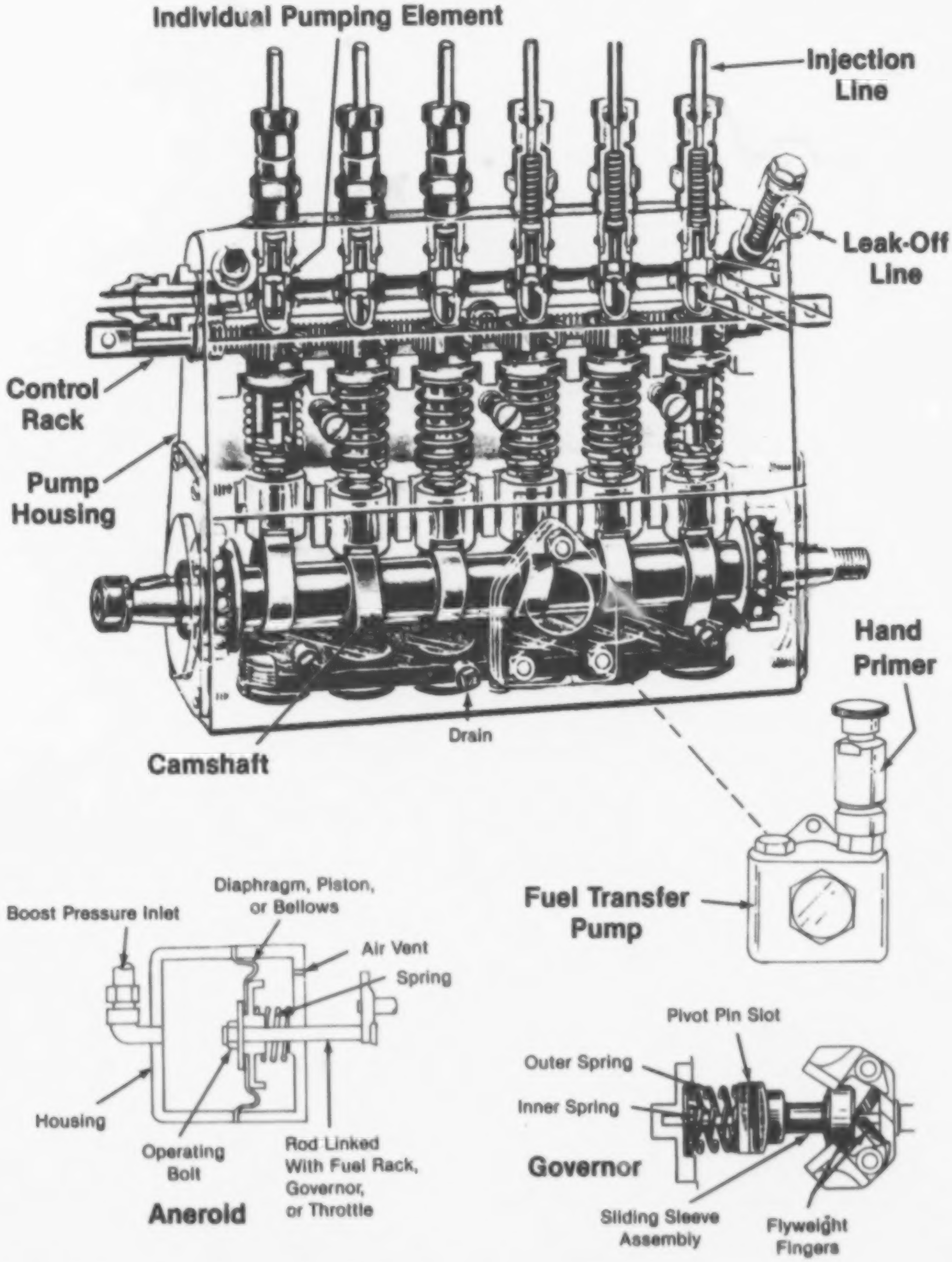
N. SE-2351 — Fixture, pump holding

In-Line Injection Pump


Shut-Off Stop Screw
Shut-Off Lever
Supply Pump
Aneroid
High Idle Stop
Throttle Lever
Timing Pointer Plug
RQV Governor Housing
Mounting Adapter
Hand Primer Pump

Courtesy of Navistar International, Inc.

Main Pump Parts


Individual Pumping Element
Injection Line
Leak-Off Line
Control Rack
Pump Housing
Hand Primer
Drain
Camshaft
Fuel Transfer Pump
Boost Pressure Inlet
Diaphragm, Piston, or Bellows
Air Vent
Spring
Housing
Operating Bolt
Rod Linked With Fuel Rack, Governor, or Throttle
Aneroid
Pivot Pin Slot
Outer Spring
Inner Spring
Governor
Sliding Sleeve Assembly
Flyweight Fingers

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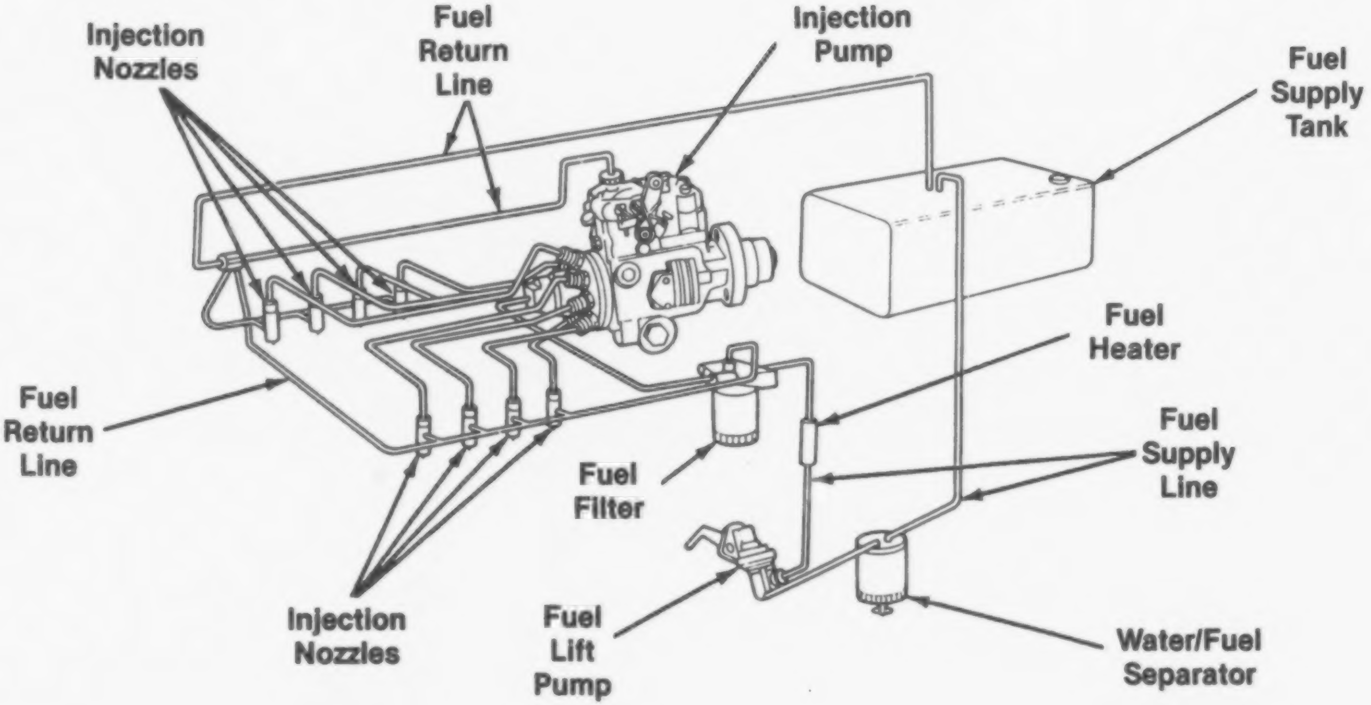
Fuel Flow


Injection Nozzles
Fuel Return Line
Injection Pump
Fuel Supply Tank
Fuel Heater
Fuel Return Line
Fuel Supply Line
Fuel Filter
Injection Nozzles
Fuel Lift Pump
Water/Fuel Separator

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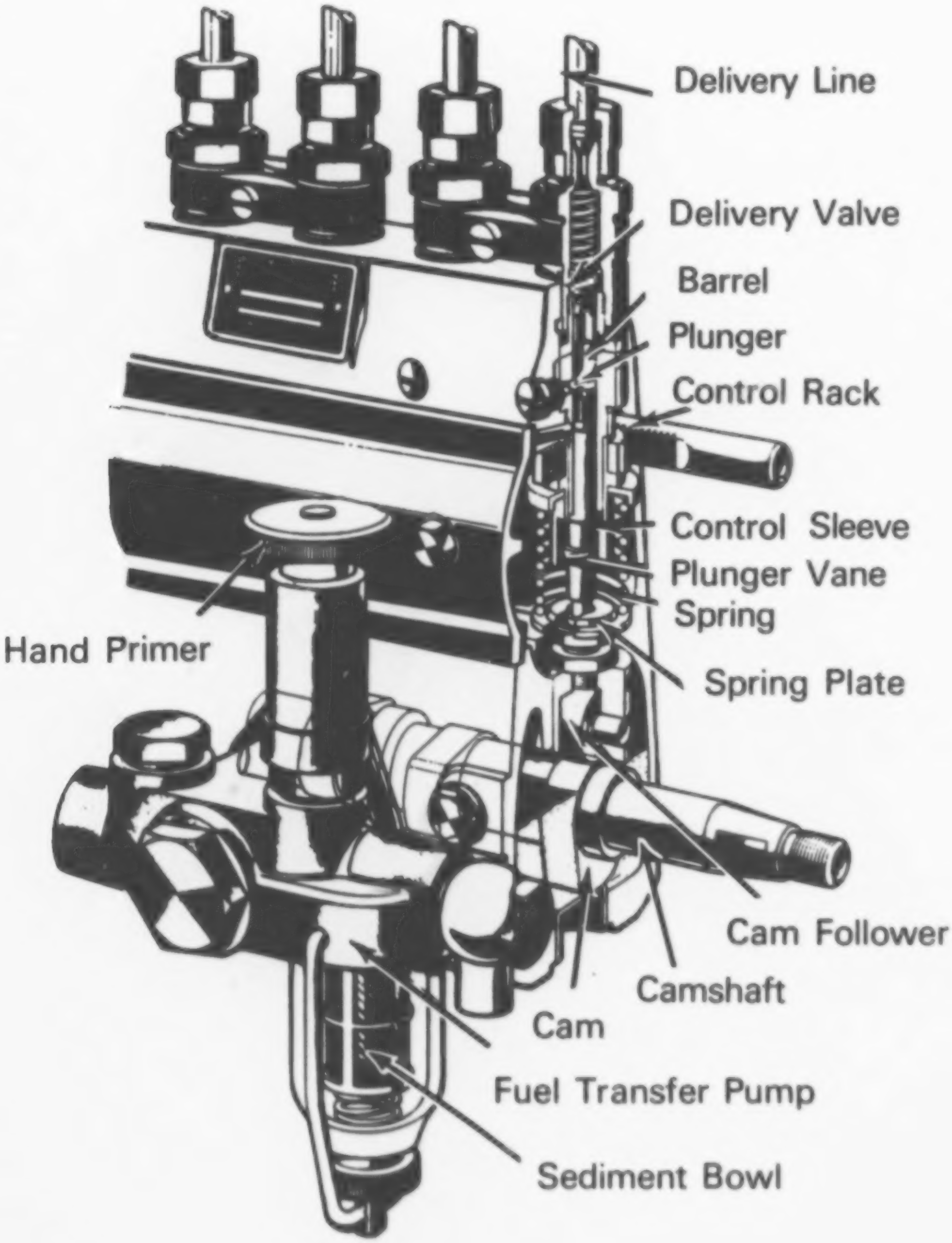
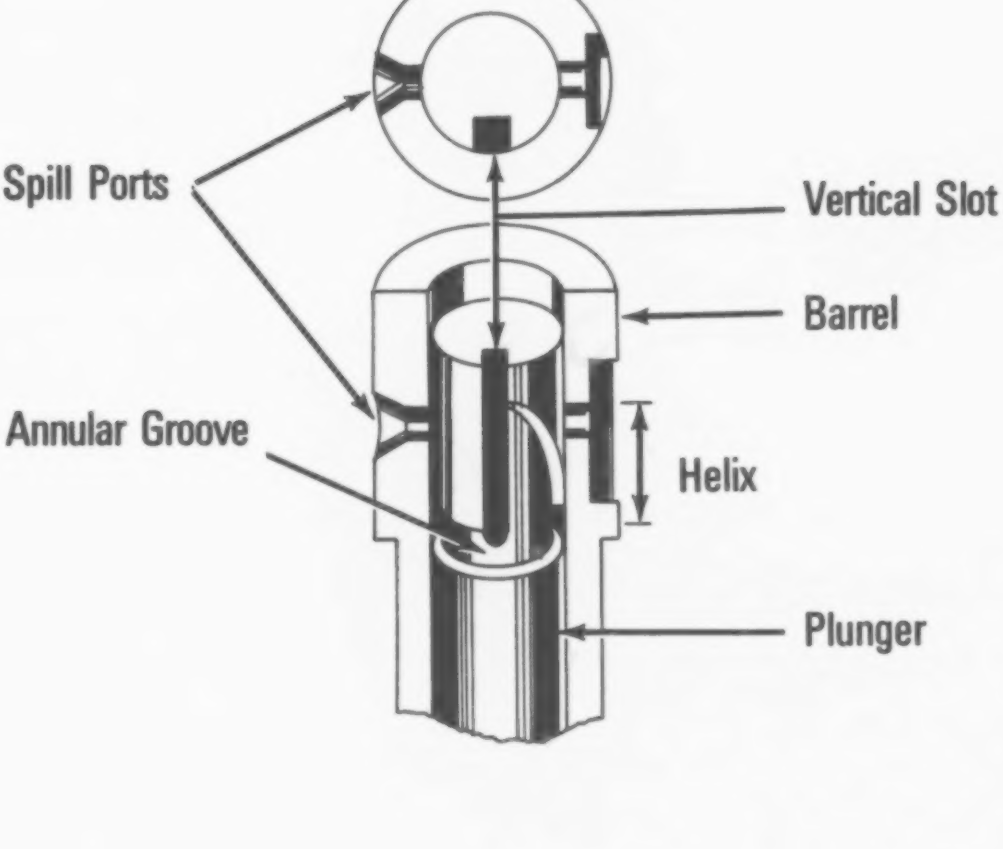
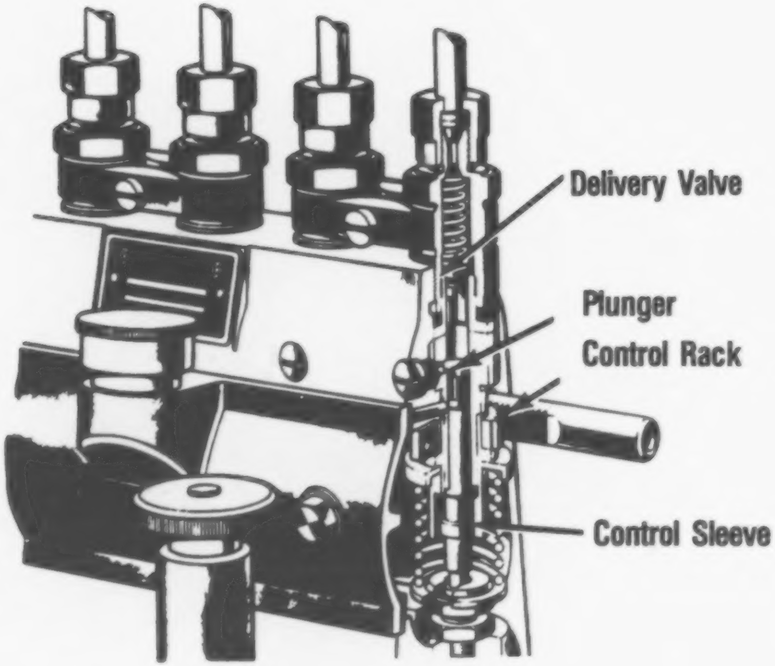
Injection Pump Operation


Delivery Line
Delivery Valve
Barrel
Plunger
Control Rack
Control Sleeve
Plunger Vane
Spring
Spring Plate
Hand Primer
Cam Follower
Camshaft
Cam
Fuel Transfer Pump
Sediment Bowl

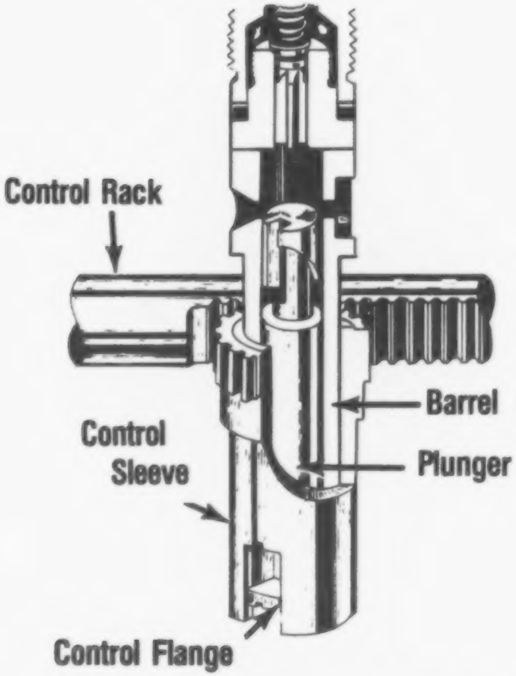
Parts And Design Features of a Pumping Element


Spill Ports
Vertical Slot
Barrel
Annular Groove
Helix
Plunger

Control Rack And Sleeve


Delivery Valve
Plunger
Control Rack
Control Sleeve

Control Rack, Sleeve, and Delivery Valve


Control Rack
Barrel
Control
Sleeve
Plunger
Control Flange

Plunger Rotation Mechanism

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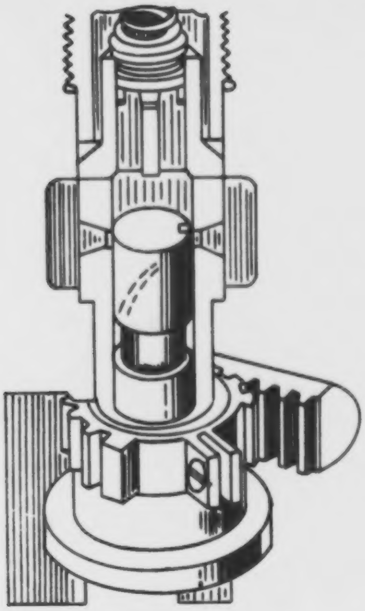
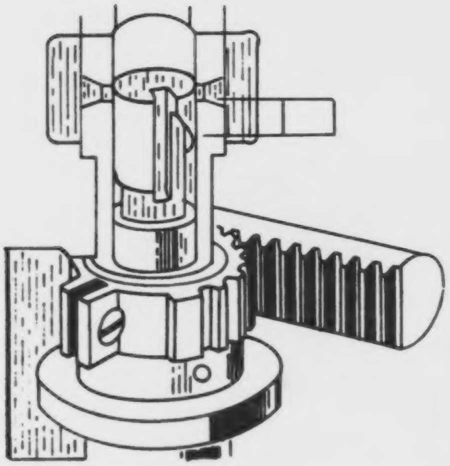
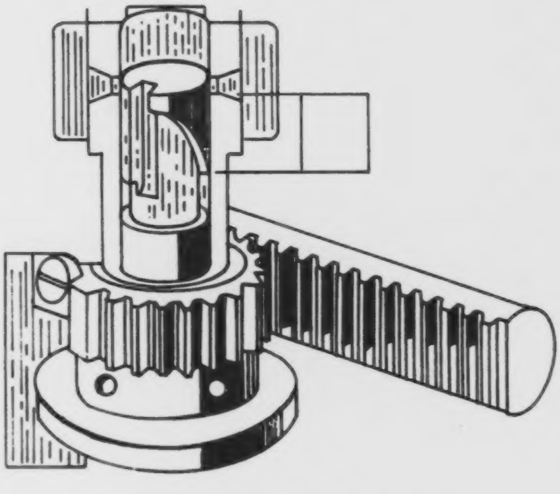
Plunger Positions At Start of Fuel Delivery



No Fuel Delivery

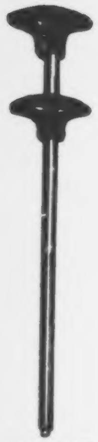


Partial Fuel Delivery



Maximum Fuel Delivery

Special Rebuild Tools



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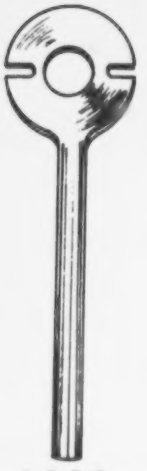

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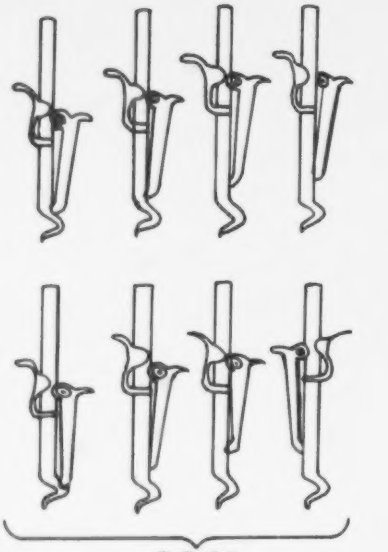

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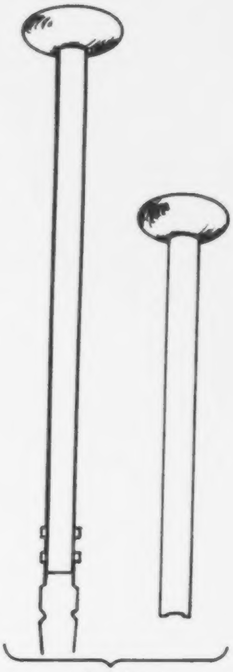

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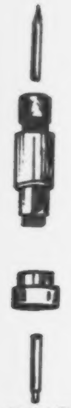

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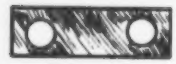

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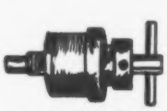

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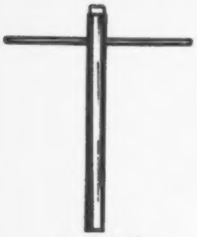

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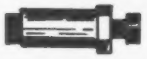

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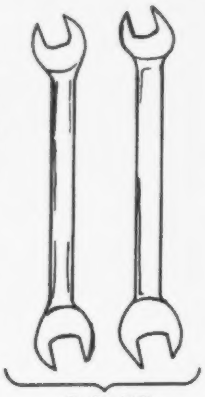

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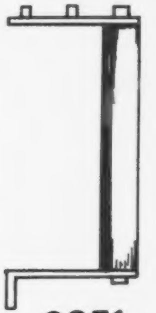

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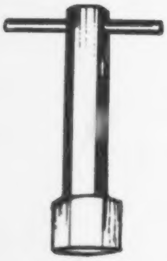

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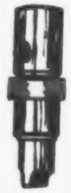

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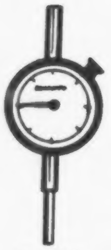


2121

IN-LINE INJECTION PUMP
UNIT V

JOB SHEET #1 — REMOVE AN IN-LINE PUMP

A. Tools and materials

1. Basic hand tool set, including metric
2. Appropriate service manual
3. Clean shop towels
4. Clean line plugs
5. Clean diesel fuel

B. Procedure

(CAUTION: Follow all shop safety procedures.)

(NOTE: Engine should be static timed before parts are removed.)

1. Disconnect and remove accelerator rod and shut-off control cable from governor.

   (NOTE: Before removing fuel lines, clean pump and connections with clean diesel fuel.)

2. Disconnect injection lines, low pressure lines, and lube oil line from pump.
3. Remove any brackets necessary.
4. Install protective caps on all fuel lines and pump outlets.
5. Remove pump stabilizing brackets.
6. Remove adapter mounting bolts which hold pump adapter and pump housing to rear of engine front cover.
7. Pull pump to rear to free drive flange tangs from middle disc.
8. Lift pump from the engine.

IN-LINE INJECTION PUMP
UNIT V

JOB SHEET #2 — OVERHAUL AN IN-LINE PUMP

A. Tools and materials

1. Basic hand tool set, including metric
2. Appropriate service manual
3. Typical tools as recommended by appropriate manufacturer.

   (NOTE: The tool numbers listed below are International Harvester.)

   a. SE-2339 Wrench, holding, drive flange
   b. SE-2340 Remover, governor flyweight damper
   c. SE-2341 Holder, tappet
   d. SE-2344 Remover and installer, camshaft cylindrical nut
   e. SE-2345 Remover and installer, tappet
   f. SE-2351 Fixture, pump holding
4. Clean pans
5. Clean shop towels (lint-free)
6. Clean tools
7. Clean work area
8. Clean work bench
9. Clean vise

B. Procedure

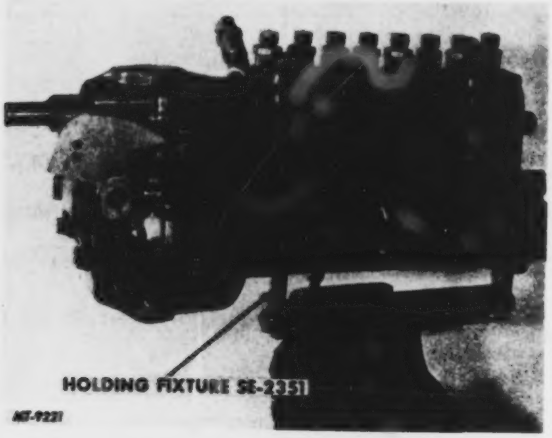
1. Disassemble governor

   a. Clean the external parts of the pump thoroughly before disassembly.
   b. Drain fuel and lubricating oil from pump and governor housings.
   c. Cap or plug fuel and lube oil openings after draining.
   d. Clean the exterior of the governor and pump housing with clean diesel fuel.

JOB SHEET #2

e. Clamp holding fixture SE-2351 in the vise and secure injection pump with two bolts. (Figure 1)

FIGURE 1

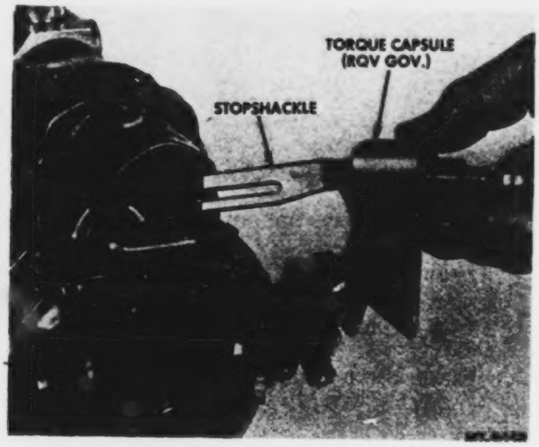

HOLDING FIXTURE SE-2351
MT-9221

f. Use a 10 mm Allen wrench, and remove plug from rack link adjustment access hole in top of governor housing.

g. Remove seal and remove rack mounting bolts on pumps with a control rack stop.

(NOTE: On pumps with torque capsule, remove seal wire, remove torque capsule cover and gasket, and remove torque capsule mounting screw bushings. See Figure 2.)

FIGURE 2


TORQUE CAPSULE (RQV GOV.)
STOPSHACKLE

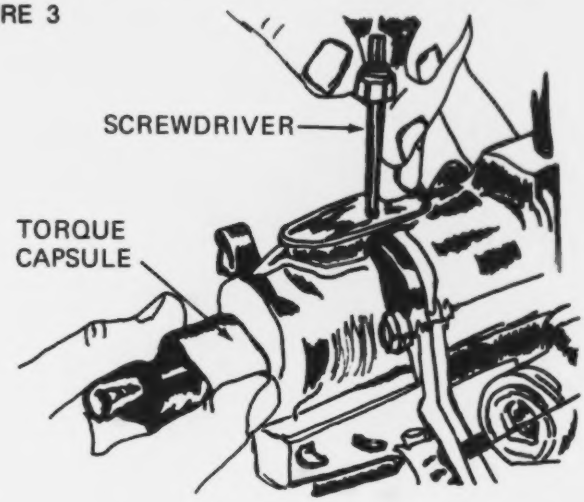
JOB SHEET #2

h. Move accelerator lever fully back against low idle stop screw.

i. Reach through the rack link access hole with a small screwdriver. (Figure 3)

j. Pry stop shackle aside lightly (right side as viewed from the rear of pump) and disengage stop shackle from rocker arm pin. (Figures 2 and 3)

FIGURE 3

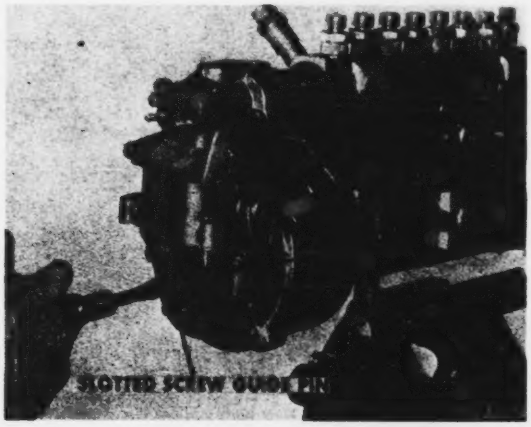


k. Pull control rack stop or torque capsule to the rear to clear mounting studs.

l. Rotate assembly approximately 45 degrees counterclockwise and slide out of governor housing.

m. Remove slotted screw guide pin from governor cover. (Figure 4)

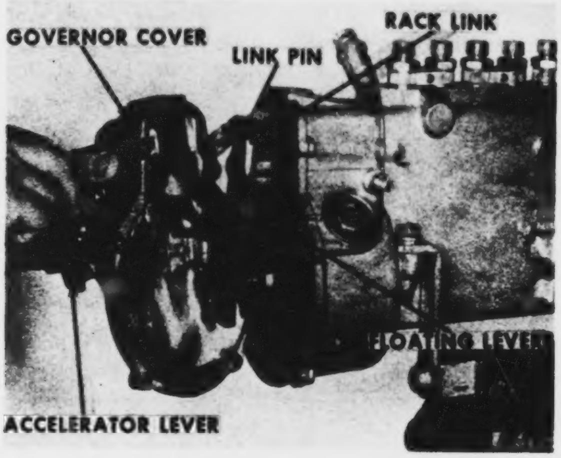
FIGURE 4



JOB SHEET #2

n. Remove mounting screws and take off governor cover. (Figure 5)

FIGURE 5


GOVERNOR COVER
LINK PIN
RACK LINK
FLOATING LEVER
ACCELERATOR LEVER

o. Operate accelerator lever to release linkage.

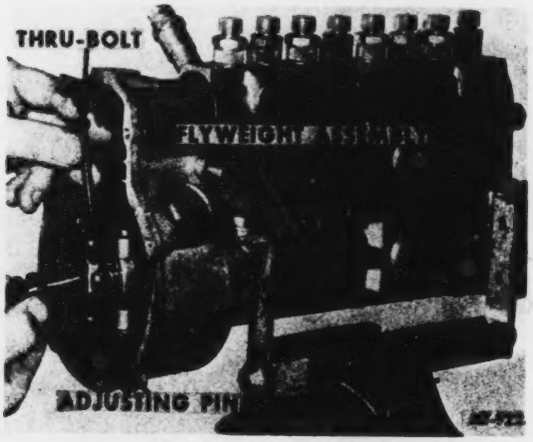
p. Remove cotter pin and link pin.

q. Disconnect floating lever from rack link.

r. Pull top of floating lever back and down to remove floating lever and slider from adjusting pin.

s. Raise tabs on lock washer and remove double-nutted thru-bolt and adjusting pin from the governor flyweight assembly. (Figure 6)

FIGURE 6


THRU-BOLT
FLYWEIGHT ASSEMBLY
ADJUSTING PIN

JOB SHEET #2

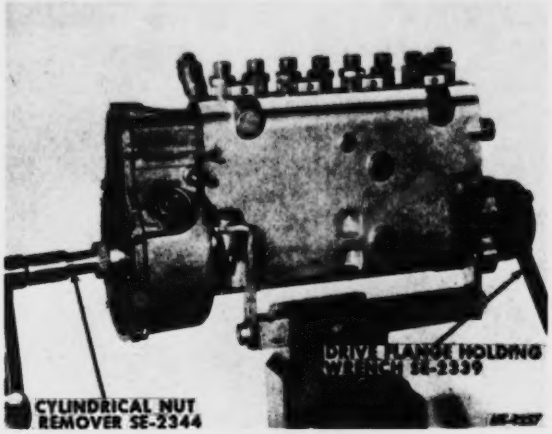
t. Raise the tabs on the lock plates.

u. Remove the two cap screws.

v. Take out the adjusting pin guide bushing.

w. Use the SE-2344 remover tool on the slotted cylindrical nut and SE-2339 holding wrench to hold the camshaft. (Figure 7)

FIGURE 7


DRIVE FLANGE HOLDING WRENCH SE-2339
CYLINDRICAL NUT REMOVER SE-2344

x. Remove the cylindrical nut and spacer shim.

y. Wire the nut and shim together.

z. Install the SE-2340 governor flyweight remover tool. (Figure 8)

FIGURE 8

GOVERNOR FLYWEIGHT REMOVER TOOL SE-2340

JOB SHEET #2

aa. Remove the flyweight assembly.

(NOTE: Do not disassemble any further.)

bb. Remove the rack link, link bracket, and spring from the rear of the control rack to remove the governor housing.

2. Disassemble in-line pump.

(NOTE: The main body contains several fittings, bushings, and plugs on which Loc-Tite has been used. Do not remove these parts unless they are leaking. Among these are the inlet fuel adapter, the fuel gallery plug, the lube oil inlet bushing, and the bleeder valve bushing.)

a. Remove the side cover.

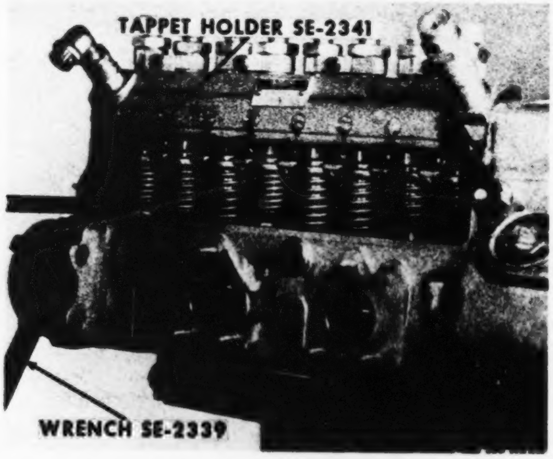
b. Remove side cover gasket from cover and housing.

c. Remove transfer pump and gasket.

d. Install eight SE-2341 tappet holder tools (Figure 9) inside of pump to hold all tappets up from the camshaft.

(NOTE: To prevent tool breakage, lift each tappet by rotating camshaft before installing holder tool.)

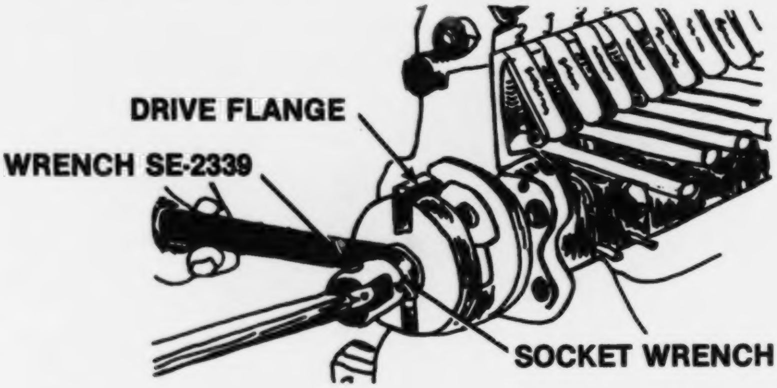
FIGURE 9



JOB SHEET #2

e. Remove camshaft nut and washer using SE-2339 holding wrench to hold drive flange. (Figure 10)

FIGURE 10



f. Remove the drive flange by using a gear puller or by removing the two socket head set screws, flat washers, and lock washers from the drive flanges; reinstall the set screws and place two steel strips behind the drive flange; run the screws in evenly until flange is removed.

(NOTE: Do not lose the woodruff key.)

g. Rotate pump in holder so that the tappet holder tools are pointing upwards.

h. Remove the two camshaft center bearing screws from the bottom of the pump.

i. Use a large screwdriver and remove the four flat head screws from camshaft front bearing retainer.

j. Remove container.

k. Remove camshaft, including center and end bearings from front of pump.

(NOTE: Mark cam position when removing.)

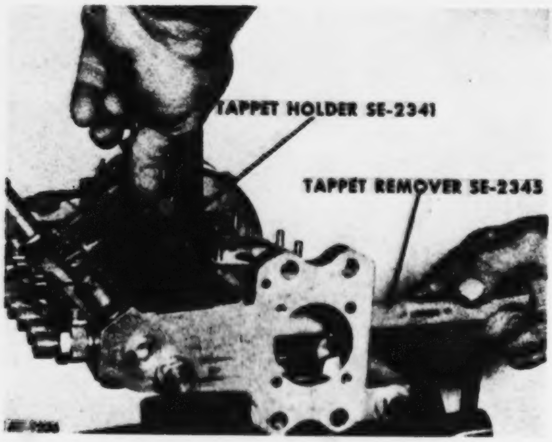
l. Use a ⁵/₈" socket and drive the eight base plugs inside the governor housing and remove them.

m. Use the SE-2345 tappet remover tool and push the roller tappet up. (Figure 11)

JOB SHEET #2

n. Remove tappet holder tool SE-2341. (Figure 11)

FIGURE 11

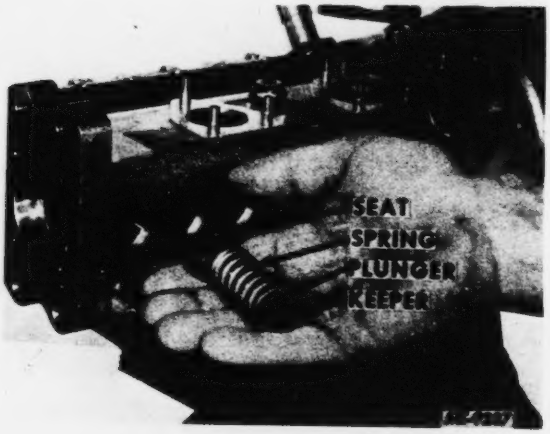

TAPPET HOLDER SE-2341
TAPPET REMOVER SE-2343

o. Remove roller tappet assemblies from pump.

(NOTE: Keep parts in order.)

p. Remove keepers, plunger springs, upper spring seats, and plungers. (Figure 12)

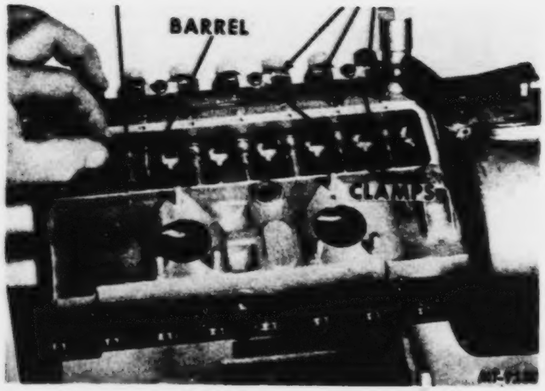
FIGURE 12


SEAT
SPRING
PLUNGER
KEEPER

JOB SHEET #2

q. Remove the control sleeves. (Figure 13)

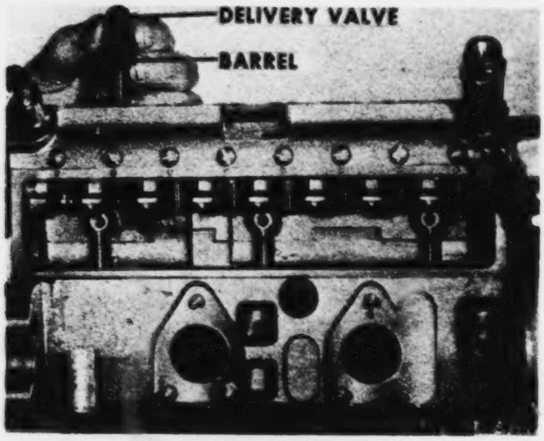
FIGURE 13



r. Remove delivery valve holder clamps; use a 7/8" socket and remove the holders.

s. Lift up on the barrels from inside the pump housing. (Figure 14)

FIGURE 14



t. Remove the delivery valves, springs, fillers, and gaskets.

(NOTE: These parts are mated at assembly — keep them in order.)

u. Remove the control rack positioning screw.

v. Pull control rack from the pump housing.

w. Remove the control rack end plug.

IN-LINE INJECTION PUMP
UNIT V

JOB SHEET #3 — CLEAN AND INSPECT IN-LINE PUMP COMPONENTS

A. Tools and materials

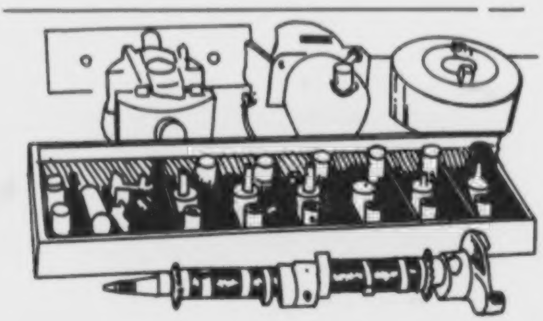
1. Appropriate service manual
2. Clean shop towels (lint-free)
3. Crocus cloth
4. Clean diesel fuel
5. Clean parts tray

B. Procedure

(CAUTION: Follow all shop safety procedures.)

1. Clean and inspect all parts before reassembling to the pump.
2. Use clean fuel oil or approved solvent to wash parts. (Figure 1)

FIGURE 1



(NOTE: When inspecting for damage or wear, it is good practice to replace any part that is questionable.)

3. Look for the following items when inspecting for damage or wear.
   a. Governor housing and cover should be inspected for cracks, stripped threads, and burrs.

JOB SHEET #3

b. Governor weight assembly should be checked for worn bell cranks, damaged weights, stripped nuts, and worn springs.

c. Damper hub assembly should be checked for condition of rubber bumpers.

d. Curve template sliding parts should not bind any grooves or pressure marks or curve should be smoothed with fine emery.

e. Adjusting pin should be inspected for wear and replaced if any is visible.

f. Pump housing should be inspected for cracks, chips, overtorquing or stripped screw threads; if the housing leaks, it cannot be repaired.

g. Plungers and barrels should be inspected for scoring and scratches.

h. Barrels and plungers can be tested by washing in test oil, and pulling the plunger part way out of the barrel; the plunger must fall back slowly by its own weight.

i. Delivery valve and seat should be replaced if any damage is present.

j. Roller tappets can be polished with crocus cloth; if tappets do not polish out, they must be replaced.

k. Camshaft should be inspected for grooving on cams and bearing surfaces; if damaged, the camshaft must be replaced.

l. Roller bearings should be replaced if worn.

m. Control rack needs to be checked for binding in the housing; the gear teeth should be checked for burrs and scratches.

n. Control sleeves can be polished and reused if only minor damage is present.

o. Spring can be reused if not broken or rusted.

p. Spring keepers can be reused unless bent or worn.

q. Base plugs can be reused unless they are known to be leaking.

r. Replace all gaskets, seals, and O-rings.

Obtain instructor's initials here ____________.

IN-LINE INJECTION PUMP
UNIT V

JOB SHEET #4 — REASSEMBLE AN IN-LINE PUMP

A. Tools and materials

1. Basic hand tool set, including metric
2. Appropriate service manual
3. Typical tools as recommended by appropriate manufacturer

   (NOTE: The tool numbers listed below are International Harvester.)

   a. SE-1848 Dial indicator set
   b. SE-2341 Holder, tappet
   c. SE-2342 Gauge, camshaft protrusion
   d. SE-2343 Holder, dial indicator
   e. SE-2345 Remover and installer, tappet
   f. SE-2351 Fixture, pump holding
4. Fuel oil or calibrating oil
5. Clean pans
6. Clean shop towels (lint-free)
7. Clean tools
8. Clean work area
9. Clean work bench
10. Clean vise

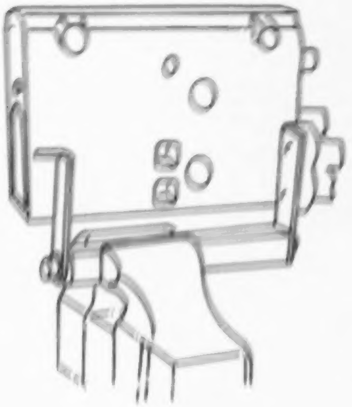
JOB SHEET #4

B. Procedure

(CAUTION: Follow all shop safety procedures.)

1. Position pump body in SE-2351 holder and clamp upright in vise. (Figure 1)

   FIGURE 1



   a. Place new gasket on governor housing.

   b. Coat the gasket with a light lubricant and install the governor housing by tapping lightly with a soft hammer.

   c. Install and stake governor mounting screws.

2. Rebuild main pump

   a. Place the barrels in correct order, aligning the guide slots with pins in pump housing.

      (NOTE: Prelubricate with fuel oil while installing.)

   b. Install delivery valves and seats.

   c. Install delivery valve gasket.

   d. Install springs.

   e. Install fill piece and holders.

   f. Use new O-rings and prelubricate with fuel oil.

   g. Install delivery valve holders finger tight.

JOB SHEET #4

h. Attach rack link bracket and rack link to the rack.

i. Place rack spring and washers in place on rack.

j. Install the control rack through the governor and into the pump housing.

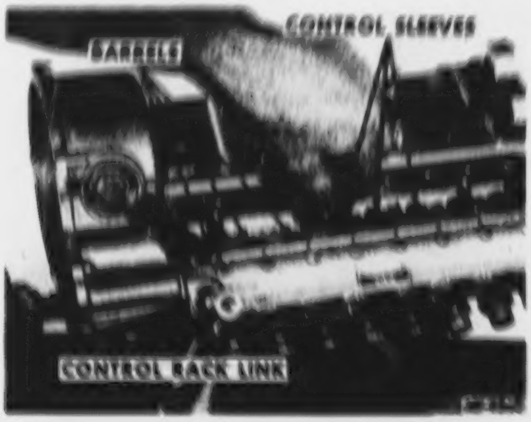
(NOTE: The rack spring is important; it takes up lost motion in the internal pump parts and serves to retract rack if other linkage should fail.)

k. Make sure the rack is free and secure it with the rack positioning screw.

l. Rotate pump so the tappet cover side is up.

m. Install control sleeves on barrels. (Figure 2)

FIGURE 2



n. Center and time all eight control sleeves on the rack segments.

o. Move the control rack to see if any sleeves bind and replace any that do.

(NOTE: When a sleeve binds, replace with the next smaller size.)

Obtain instructor's initials here ______________ before proceeding to next step.

p. Start at the drive end and torque #1 through #8 delivery valve holders 22 to 25 ft. lbs.

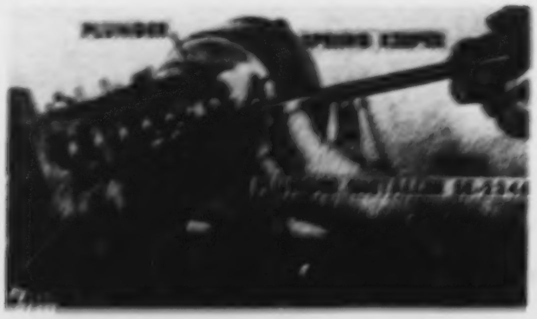
(NOTE: Torque twice. Torque, loosen, retorque.)

q. Install the upper spring seats and springs.

JOB SHEET #4

r. Use the plunger installer tool. (Figure 3)

FIGURE 3



s. Place the spring keeper on the tool.

t. With marked tong of plunger toward side cover opening and open end of spring keeper away from side cover opening, install plungers and spring keepers in their respective barrels.

u. Align the plunger tong with the control slot.

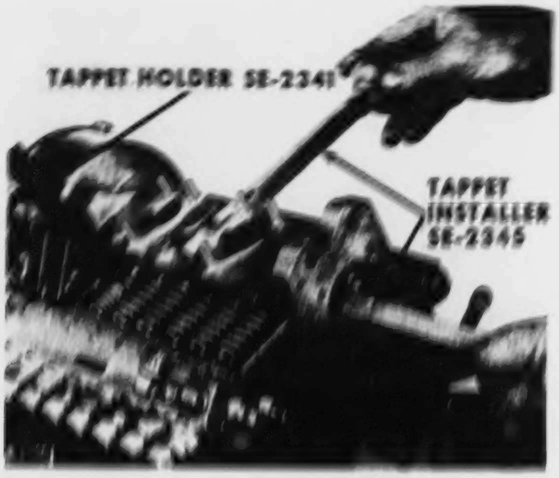
v. Use the SE-2345 tappet installation tool, taking care to keep the roller pin flush with the tappet.

w. Compress the plunger springs with SE-2345 tappet installation tool. (Figure 4)

JOB SHEET #4

x. Position all eight SE-2341 tappet holder tools on side of pump housing to hold all tappets in their raised position. (Figure 4)

FIGURE 4



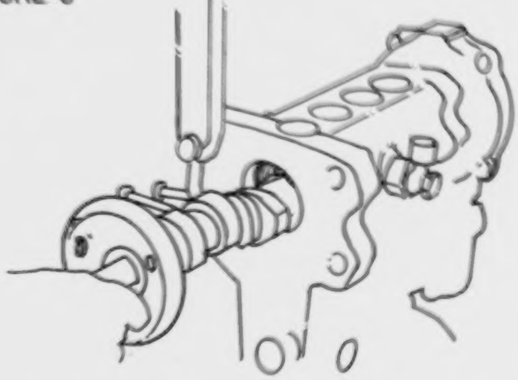
Obtain instructor's initials here ____________ before proceeding to next step.

y. Place a small dab of grease on the center bearing to hold it to the camshaft.

(NOTE: Use white grease. Lubriplate® is good.)

z. Install the camshaft into the pump housing. (Figure 5)

FIGURE 5



aa. Secure the center bearing with two screws through the bottom of the pump housing.

JOB SHEET #4

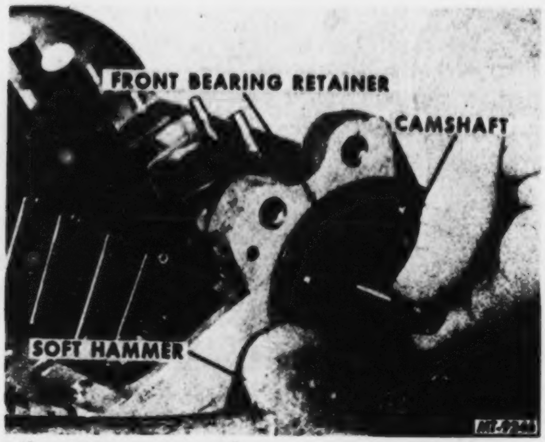
bb. Use a thin coat of non-hardening sealer on the front bearing retainer and set retainer in place.

cc. Start all four screws to guide the retainer in place.

(NOTE: Do not use screws to draw the retainer down, just to guide.)

dd. Tap retainer into place while turning the camshaft to assure alignment. (Figure 6)

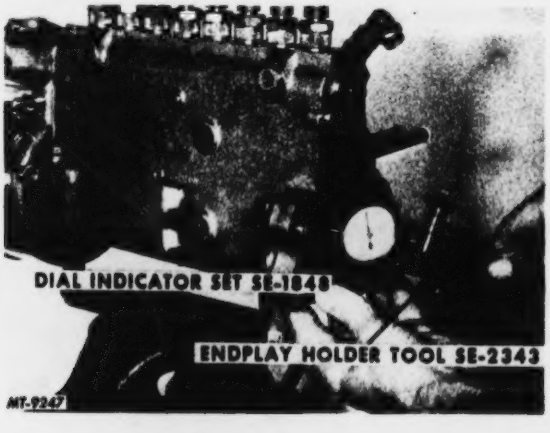
FIGURE 6


FRONT BEARING RETAINER
CAMSHAFT
SOFT HAMMER

ee. Tighten mounting screws securely.

ff. Check camshaft end play. (Figure 7)

FIGURE 7


DIAL INDICATOR SET SE-1848
ENDPLAY HOLDER TOOL SE-2343
MT-9247

JOB SHEET #4

gg. Screw SE-2343 holder tool onto front end of camshaft.

hh. Place SE-1848 dial indicator set in holder so indicator will read end play when tool handle is pulled and released.

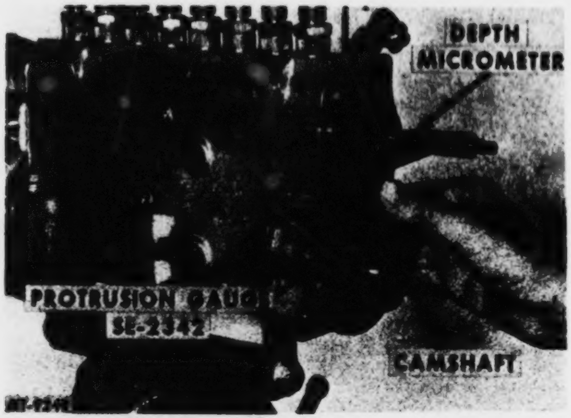
(NOTE: Rotate cam first.)

ii. Set end play to manufacturer's spec's.

jj. Change end play by adding or removing shims behind the front bearings.

kk. Check camshaft protrusion. (Figure 8)

FIGURE 8



ll. Check space between the drive coupling and main body; use the SE-2342 protrusion gauge and depth micrometer.

mm. Place gauge over front end of camshaft.

nn. Use the depth micrometer and measure from the surface of the tool to the machined surface of the pump housing.

oo. Check the distance; it should be to manufacturer's spec's.

pp. Change camshaft protrusion by adding shims under the bearing at the governor end of the camshaft.

qq. Install woodruff key in camshaft slot.

rr. Install the drive flange on camshaft.

JOB SHEET #4

ss. Install lock washer and nut and tighten to 60-72 ft. lbs.

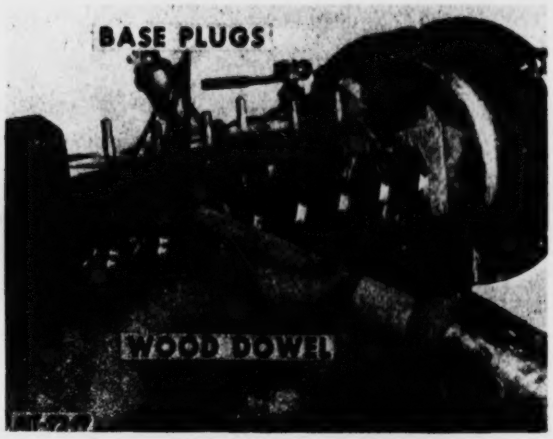
(NOTE: Check the two halves of the drive flange to be sure mating marks are together. Torque the socket head set screws in drive flange 18-25 ft. lbs.)

Obtain instructor's initials here ______________ before proceeding to next step.

tt. Use the camshaft to release pressure on the SE-2341 tappet holder tools and remove them from the side of the housing.

uu. Install the base in the bottom of the pump housing using 5/8" or 11/16" socket or similar size wood dowel. (Figure 9)

FIGURE 9



vv. Seat plugs so they are just past the lower edge of chamfer in the pump housing.

ww. Install a new gasket and transfer pump to side of pump housing.

xx. Secure with three mounting nuts and lock washers.

(NOTE: You can check the condition of the transfer pump by pressurizing with air (15-20 psi) and submerging in oil — no leaks are permitted.)

IN-LINE INJECTION PUMP
UNIT V

JOB SHEET #5 — REASSEMBLE THE R.Q.V. GOVERNOR

A. Tools and materials

1. Basic hand tool set
2. Appropriate service manual
3. Typical tools as recommended by appropriate manufacturer

   (NOTE: The tool numbers listed below are International Harvester.)

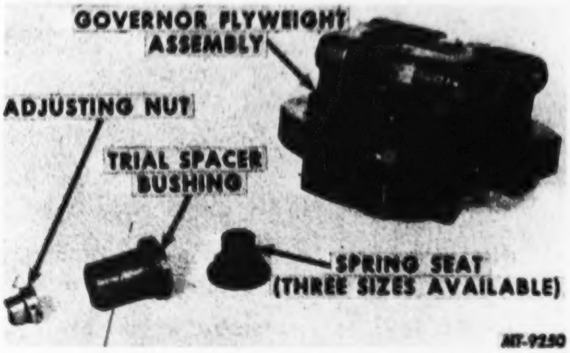
   a. SE-2339 Wrench, holding, drive flange
   b. SE-2344 Remover and installer, camshaft cylindrical nut
4. Manufacturer's specifications
5. Clean shop towels

B. Procedure

(CAUTION: Follow all shop safety procedures.)

1. Service the governor flyweight assembly as a complete unit. (Figure 1)

   FIGURE 1


GOVERNOR FLYWEIGHT ASSEMBLY
ADJUSTING NUT
TRIAL SPACER BUSHING
SPRING SEAT (THREE SIZES AVAILABLE)
MT-9250

JOB SHEET #5

2. Service weight springs, spring seats, and shims individually, as follows.

   a. Perform a static check on balanced movement of governor weights by making a temporary build-up less the springs.

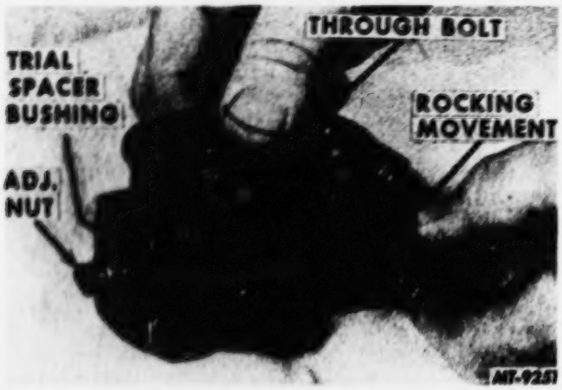
   b. Use the spring seats, trial spacer bushings, and adjusting nuts on each weight as follows.

   (NOTE: Trial spacer bushings can be purchased from most fuel labs.)

   c. Install double-nutted thru-bolt in the weight assembly.

   d. Apply slight pressure to center of bolt and check for excessive rocking movement in either weights. (Figure 2)

   FIGURE 2



   e. Use the correct size spring seat so that slight movement in the weights can be equalized.

   (NOTE: When installing the three different size weight springs, remove the trial spacer bushings.)

   f. Reinstall the flyweight springs; always start governor spring reassembly with one shim under the lo-idle (large) spring, two shims under the intermediate spring, and no shims under hi-idle (small) spring.

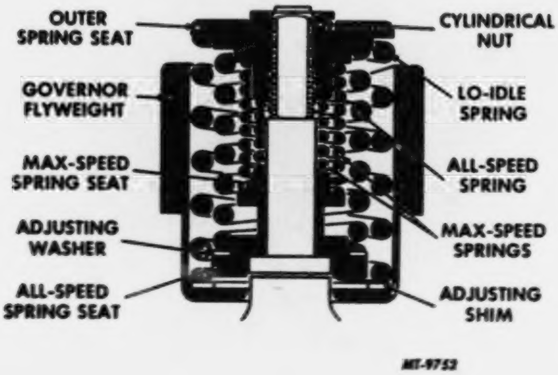
   (NOTE: The intermediate spring shims may change when the pump is calibrated; always reinstall the same color spring as was removed.)

   g. Install the outer spring seat and adjusting nut.

JOB SHEET #5

h. Install the outer spring seat and adjusting nut. (Figure 3)

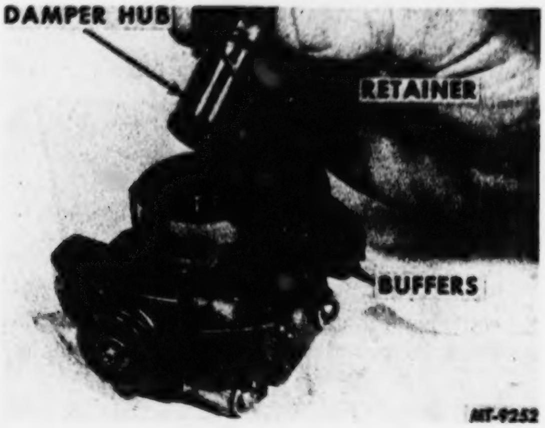
FIGURE 3


OUTER SPRING SEAT
GOVERNOR FLYWEIGHT
MAX-SPEED SPRING SEAT
ADJUSTING WASHER
ALL-SPEED SPRING SEAT
CYLINDRICAL NUT
LO-IDLE SPRING
ALL-SPEED SPRING
MAX-SPEED SPRINGS
ADJUSTING SHIM
MT-9752

(NOTE: The adjustment range is from flush to not more than 2.5 mm [.100"], protrusion of the threaded bolt [2 to 3 clicks]. Post protrusion should be approximately equal on both spring sets.)

3. Inspect damper buffers for damage and pry up the hub to inspect and replace as a set, if needed, before installing weight assembly on camshaft. (Figure 4)

FIGURE 4

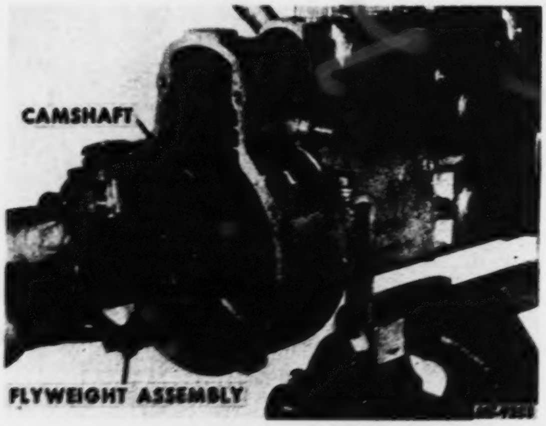

DAMPER HUB
RETAINER
BUFFERS
MT-9252

JOB SHEET #5

4. Assemble the prelubricated buffers in damper retainer and place damper hub on weight assembly. (Figure 4)

   a. Install the flyweight assembly to the camshaft. (Figure 5)

      FIGURE 5



   b. Install spacer shim and secure to camshaft with slotted cylindrical nut, using the SE-2344 and SE-2339 rebuild tools, and torque the nut to 37-43 ft. lbs.

   c. Check action of damper by holding camshaft, grasping weight assembly, and twisting to note for slight movement.

   d. Use a thicker spacer shim to obtain more movement or thinner shim to decrease movement.

   e. Install the adjusting pin guide bushing.

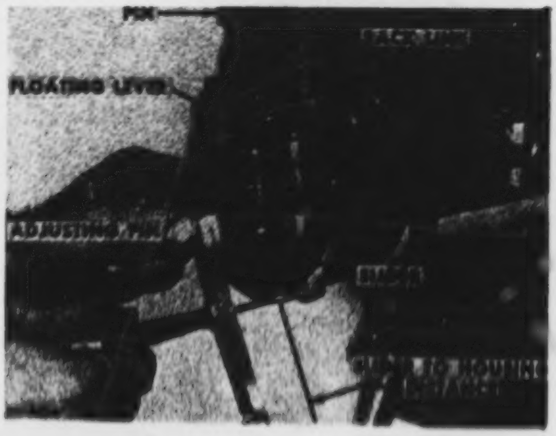
   f. Install adjusting pin assembly; temporarily secure with the thru-bolt at this time.

   g. Install slider and floating lever; open slot of the floating lever to right, and pin floating lever to rack link to hold in place.

JOB SHEET #5

h. Measure the slider-to-housing distance. (Figure 6)

FIGURE 6


PIN
FLOATING LEVER
ADJUSTING PIN
SLIDER TO HOUSING DISTANCE

i. Take measurement by measuring from the back of the slider to the governor mating surface with no gasket 38.8 mm, 1.524 +/- .015".

j. Change the distance by turning the screw inside of the adjusting pin; one-half turn of the adjusting screw moves sliding block approximately .5 mm, .020".

k. Secure the double-nutted thru-bolt in the governor weight assembly by installing the lock washer and nut; move the rack and check for freedom of movement.

(CAUTION: Do not overtighten bolt.)

l. Back out the hi-idle adjusting screw.

m. Measure the setting of the curve plate. (Figure 7)

FIGURE 7

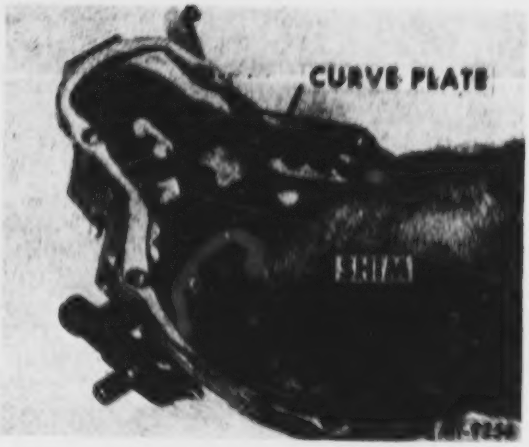
BASE SETTING
CURVE PLATE
GASKET
GUIDE PIN

JOB SHEET #5

n. Take measurement from the governor cover surface (gasket in place) to the guide pin shaft when the guide pin is in maximum fuel position and bottomed in curve plate; setting should be 21.5-21.9 mm (.847-.863"); add shims to decrease the setting. (Figure 8)

(NOTE: Make sure cotter pin has been installed between the rack link and floating lever.)

FIGURE 8



o. Install governor cover to housing.

p. Apply a non-hardening sealer to the guide stud screw and install it in the rear of the governor cover.

q. Install accelerator lever.

r. Place the accelerator lever fully back against the lo-idle stop screw.

s. Install torque capsule into governor housing, then rotate torque capsule 45 degrees in a counterclockwise direction.

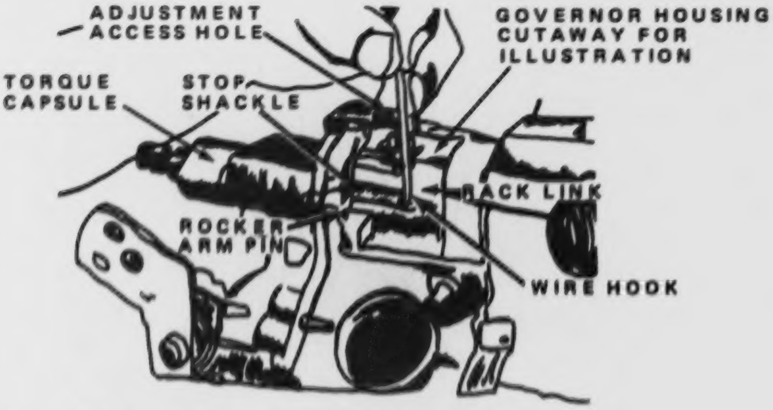
t. Slide torque capsule into governor housing until stop shackle clears governor floating lever, then rotate capsule clockwise until in a horizontal position.

u. Move the accelerator lever into a vertical position.

JOB SHEET #5

v. Use a hook made from light wire and reach down through the adjustment access hole and lift up the stop shackle to engage the slot in the stop shackle with the rocker arm pin. (Figure 9)

FIGURE 9

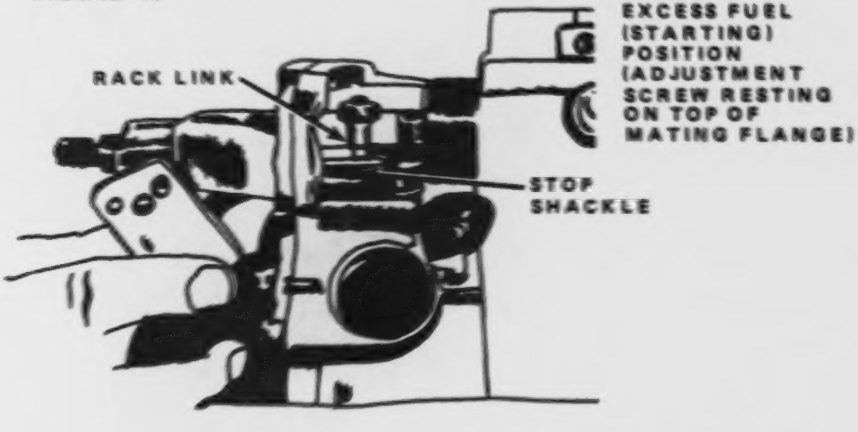

ADJUSTMENT ACCESS HOLE
GOVERNOR HOUSING CUTAWAY FOR ILLUSTRATION
TORQUE CAPSULE
STOP SHACKLE
RACK LINK
ROCKER ARM PIN
WIRE HOOK

w. Secure the torque capsule.

5. Check the torque capsule assembly.

a. Hold the accelerator lever fully forward. (Figure 10)

FIGURE 10


EXCESS FUEL (STARTING) POSITION (ADJUSTMENT SCREW RESTING ON TOP OF MATING FLANGE)
RACK LINK
STOP SHACKLE

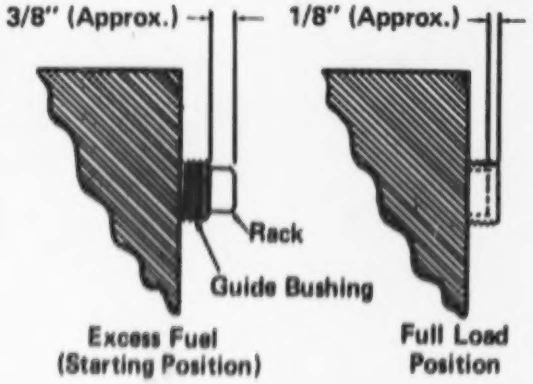
b. Move fuel shut-off lever to the rear slowly; if the installation is correct, a distinct click will be heard as the rack moves back.

(NOTE: If correct positions cannot be obtained, check for proper engagement of slot in stop shackle to rocker arm pin.)

JOB SHEET #5

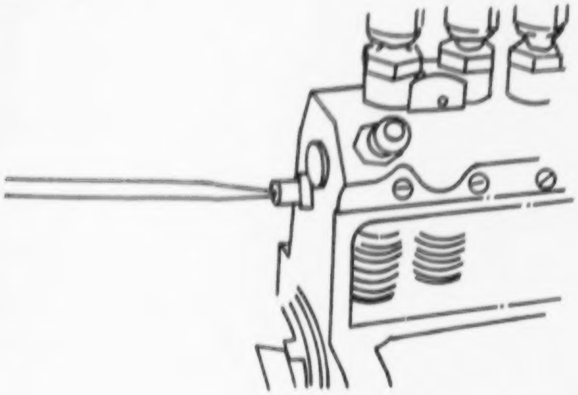
c. Check the rack position by removing the plug from the front of the pump housing (drive end); at excess fuel position (starting) the rack should extend 9.525 mm (.375") forward of the threaded guide bushing, at full load position; the end of the rack should lie approximately 3.175 mm (.125") inside of the threaded guide bushing on pump housing. (Figure 11)

FIGURE 11


3/8" (Approx.)
1/8" (Approx.)
Rack
Guide Bushing
Excess Fuel (Starting Position)
Full Load Position

d. Mount engine adapter to front of pump. (Figure 12)

FIGURE 12



Rack Stop Screw.

Diesel Engine Repair. John F. Dagel. Copyright © 1982. Reprinted by permission of John Wiley & Sons, Inc.

IN-LINE INJECTION PUMP
UNIT V

JOB SHEET #6 — BENCH TEST AN IN-LINE PUMP

A. Tools and materials

1. Basic hand tool set
2. Appropriate service manual
3. Test stand adapters
4. Test stand manual
5. Pump tools
6. Special tools
7. Pump specification sheet
8. Clean shop towels (lint-free)
9. Safety glasses

B. Procedure

(CAUTION: Follow all shop safety procedures.)

1. Use the appropriate manual for the pump you are working on and follow the procedure outlined in it.
2. Use the following chart or appropriate chart and fill in the appropriate blanks when testing the pump.

JOB SHEET #6

Engine Size —
Calibrating Stand —
Accessory Set —
Calibrating Oil —
Supply Pressure —
Nozzle Opening Pressure —

Pump Type and # —
Pre-Stroke Setting - Plunger —
Camshaft Phasing —

Transfer Pump Pressure
@ 1500 RPM

CHECK	RPM	BHP	BHP	BHP
1. Governor Cutoff, Rack Position				
2. Hi-Idle, Rack Position				
3. Maximum Fuel a. Delivery (Average) b. Bal. Max. Spread c. Rack Pos. (Ref.)				
4. Transitions, Delivery (Average) a. High Speed @ 1-15 mm^3/Stk. 2,3,5,8 Cylinders b. Low Speed @ 1-5 mm^3/Stk. 2,3,5,8 Cylinders				
5. Torque Compensation a. Beginning Rack Pos. b. Max. Deliv. (Avg.) c. End Rack Position 1) 2)				
6. End of Excess Fuel, Rack Position				
7. Lo-Idle, Rack Position				
8. Shut-Off, Rack Position				
9. Static Timing				

IN-LINE INJECTION PUMP
UNIT V

JOB SHEET #7 — TIME AN IN-LINE PUMP (MACK)

A. Tools and materials

1. Portable high pressure PC (port closing) timer (Bacharach Part #72-7010)
2. High pressure hand pump (Robert Bosch Part #1 687 222 039)
3. Timing plug gauge (J25345-1 for American Bosch injection pump, J24345-2 for Robert Bosch injection pump)

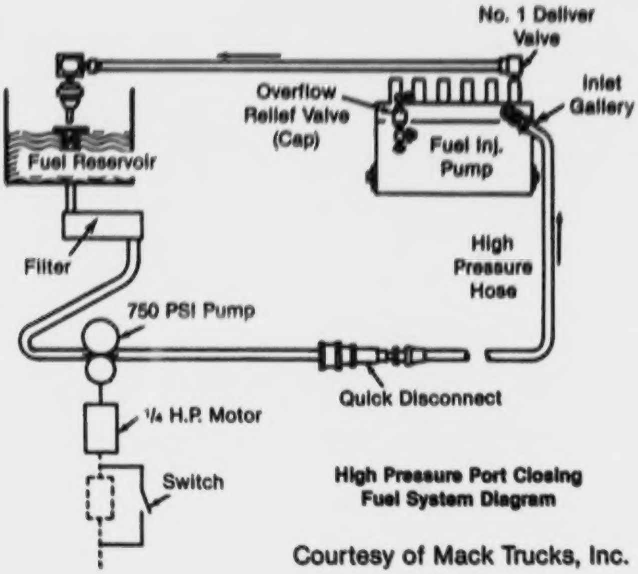
B. Procedure

(NOTE: The following method is required to set the static timing on smog certified engines.)

(CAUTION: Before timing engine, verify setting on injection pump name plate or EPA engine emission plate.)

1. Cap or connect ignition lines on all except #1 delivery valve outlet on the pump. (Figure 1)

FIGURE 1


No. 1 Deliver Valve
Overflow Relief Valve (Cap)
Inlet Gallery
Fuel Reservoir
Fuel Inj. Pump
Filter
High Pressure Hose
750 PSI Pump
Quick Disconnect
¼ H.P. Motor
Switch

High Pressure Port Closing Fuel System Diagram

Courtesy of Mack Trucks, Inc.

2. Remove all return fuel lines at overflow relief valve union fittings and cap valve port connections. (Figure 1)

JOB SHEET #7

3. Connect the high pressure line from the portable PC stand to fuel inlet of the injection pump inlet. (Figure 1)

4. Connect the PC stand return line from #1 cylinder delivery valve holder to the portable PC stand. (Figure 1)

5. Check timing before any adjustments are made.

   (NOTE: On pumps with retard start device, remove the control rack plug, and insert the correct timing plug gauge, (J24345-1 for American Bosch and J24345-2 for Robert Bosch pumps.)

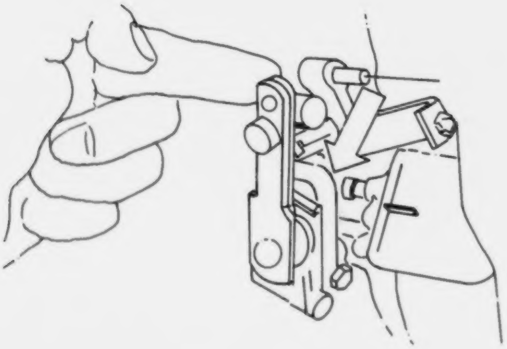
   (CAUTION: On the Mack-Scania engine equipped with a Robert Bosch pump, the damper cylinder *must* be removed from the pump to prevent cylinder damage.)

   (NOTE: Skip Step 6 for pump with no puff limiter.)

6. Apply and maintain 30 psi minimum air pressure on the puff limiter air cylinder.

7. Activate the throttle lever several times and secure in the full load position. (Figure 2)

FIGURE 2



8. Introduce fuel pressure to the pump gallery.

   (NOTE: Fuel pressure applied prior to securing throttle lever may prevent proper port closing.)

9. Slowly bar engine in normal direction of rotation, bringing #1 piston up on compression stroke.

JOB SHEET #7

10. Stop at the instant the fuel flow from #1 delivery valve changes from a solid stream to the formation of drops.

    (NOTE: This is port closing.)

11. If timing pointer is at the specified mark, the engine is timed correctly. Go to Step 18.

    Obtain instructor's initials here ____________ before proceeding to next step.

12. Shut off stand.

13. Loosen the pump drive coupling capscrews.

14. Move pump in opposite direction of rotation until the pump drive is at the end of its drive slots.

15. Snug the capscrews at this point.

16. Bring #1 piston up on compression stroke to recommended static port closing degrees BTDC.

    (NOTE: Read this on either the vibration damper or the flywheel.)

17. Repeat Steps 5 through 9.

18. Slowly turn the injection pump in direction of normal rotation until the fuel from the #1 delivery valve outlet changes from a solid stream into drops.

    (NOTE: This is port closure.)

19. Lock the drive gear capscrews.

20. Back engine up 1/4 turn.

21. Bar engine in normal direction to port closure.

22. Recheck timing.

23. If timing is correct, torque the drive gear.

24. Reconnect all lines.

    Obtain instructor's initials here ____________ before proceeding to next step.

25. Start engine and check for leaks.

    (NOTE: On Volvo engines, a dial indicator is used on pump plunger to time this engine. See service manual.)

IN-LINE INJECTION PUMP
UNIT V

PRACTICAL TEST
JOB SHEET #1 — REMOVE AN IN-LINE PUMP

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ______________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Cleaned engine properly.	______	______
3. Static timed engine before starting job.	______	______
4. Disconnected all lines.	______	______
5. Removed brackets.	______	______
6. Installed protective caps.	______	______
7. Removed adapter bolts.	______	______
8. Removed pump.	______	______
9. Checked in/put away tools and materials.	______	______
10. Cleaned the work area.	______	______
11. Used proper tools correctly.	______	______
12. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
13. Practiced safety rules throughout procedure.	______	______
14. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #1 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:				
	4	3	2	1
Static timed engine				
	4	3	2	1
Removed in orderly process				

EVALUATOR'S COMMENTS: ____________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

IN-LINE INJECTION PUMP
UNIT V

PRACTICAL TEST
JOB SHEET #2 — OVERHAUL AN IN-LINE PUMP

STUDENT'S NAME ______________________________ DATE ______________

EVALUATOR'S NAME ______________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Cleaned external parts.	______	______
3. Drained fuel and hub oil and capped.	______	______
4. Mounted in vise properly.	______	______
5. Used metric allen wrench and removed plug.	______	______
6. Removed seal and rack mounting bolts (on pumps with rack stops).	______	______
7. Removed torque capsule (if needed).	______	______
8. Removed slotted screw guide pin.	______	______
9. Removed governor cover.	______	______
10. Removed governor.	______	______
11. Removed cylindrical nut and spacer shim and wire together.	______	______
12. Removed side cover and transfer pump.	______	______
13. Installed tappet holders.	______	______
14. Removed camshaft.	______	______
15. Removed tappets.	______	______
16. Kept parts in order.	______	______
17. Removed the delivery valve holders.	______	______
18. Removed delivery valves, springs, fillers, and gaskets.	______	______
19. Placed removed parts in order.	______	______
20. Removed control rack.	______	______
21. Checked in/put away tools and materials.	______	______
22. Cleaned the work area.	______	______
23. Used proper tools correctly.	______	______
24. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
25. Practiced safety rules throughout procedure.	______	______
26. Provided satisfactory responses to questions asked.	______	______

JOB SHEET #2 PRACTICAL TEST

EVALUATOR'S COMMENTS: ____

____

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

Disassembled in proper order	4	3	2	1
Kept parts clean and in order	4	3	2	1

EVALUATOR'S COMMENTS: ____

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

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IN-LINE INJECTION PUMP
UNIT V

PRACTICAL TEST
JOB SHEET #3 — CLEAN AND INSPECT IN-LINE PUMP COMPONENTS

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ______________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Checked governor housing.	______	______
3. Checked governor weight assembly.	______	______
4. Checked damper hub assembly.	______	______
5. Checked curve template sliding parts.	______	______
6. Checked adjusting pins.	______	______
7. Checked pump housing.	______	______
8. Checked plunger and barrels.	______	______
9. Checked delivery valve and seat.	______	______
10. Checked camshaft.	______	______
11. Checked spring.	______	______
12. Checked keepers.	______	______
13. Checked in/put away tools and materials.	______	______
14. Cleaned the work area.	______	______
15. Used proper tools correctly.	______	______
16. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
17. Practiced safety rules throughout procedure.	______	______
18. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #3 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

	4	3	2	1
Found all faulty parts				

EVALUATOR'S COMMENTS: ____________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

IN-LINE INJECTION PUMP
UNIT V

PRACTICAL TEST
JOB SHEET #4 — REASSEMBLE AN IN-LINE PUMP

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ______________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:

		YES	NO
1.	Checked out proper tools and materials.	______	______
2.	Installed governor housing.	______	______
3.	Installed barrels in correct order.	______	______
4.	Installed delivery valves and seat with new gasket.	______	______
5.	Installed springs, fill piece and holder with new O-rings.	______	______
6.	Installed control rack.	______	______
7.	Installed control sleeves and timed.	______	______
8.	Torqued delivery valve holders.	______	______
9.	Installed upper spring seats and springs.	______	______
10.	Installed spring keepers and plungers.	______	______
11.	Installed camshaft.	______	______
12.	Tapped cam retainer in place.	______	______
13.	Checked camshaft end play.	______	______
14.	Checked camshaft protrusion.	______	______
15.	Torqued flange nut.	______	______
16.	Checked transfer pump.	______	______
17.	Checked in/put away tools and materials.	______	______
18.	Cleaned the work area.	______	______
19.	Used proper tools correctly.	______	______
20.	Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
21.	Practiced safety rules throughout procedure.	______	______
22.	Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #4 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

Assembled pump	4	3	2	1
Tested transfer pump	4	3	2	1

EVALUATOR'S COMMENTS: ____

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

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IN-LINE INJECTION PUMP
UNIT V

PRACTICAL TEST
JOB SHEET #5 — REASSEMBLE THE R.Q.V. GOVERNOR

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ______________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Performed static check on balanced movement.	______	______
3. Installed weight springs.	______	______
4. Installed same color spring as removed.	______	______
5. Installed outer spring seat and adjusting nut.	______	______
6. Installed fly weight assembly to camshaft.	______	______
7. Installed the adjusting pin.	______	______
8. Installed slider and floating lever.	______	______
9. Measured the slider-to-housing distance and corrected.	______	______
10. Measured and corrected the setting of the curved plate.	______	______
11. Installed governor cover to housing.	______	______
12. Installed accelerator lever.	______	______
13. Installed torque capsule.	______	______
14. Checked the torque capsule assembly.	______	______
15. Checked the rack position and corrected.	______	______
16. Checked in/put away tools and materials.	______	______
17. Cleaned the work area.	______	______
18. Used proper tools correctly.	______	______
19. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
20. Practiced safety rules throughout procedure.	______	______
21. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #5 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

	4	3	2	1
Pump is ready to bench test				

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

IN-LINE INJECTION PUMP
UNIT V

PRACTICAL TEST
JOB SHEET #6 — BENCH TEST AN IN-LINE PUMP

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ______________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Installed pump on pump stand.	______	______
3. Looked up spec's.	______	______
4. Calibrated pump.	______	______
5. Checked in/put away tools and materials.	______	______
6. Cleaned the work area.	______	______
7. Used proper tools correctly.	______	______
8. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
9. Practiced safety rules throughout procedure.	______	______
10. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #6 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

	4	3	2	1
Calibrated pump to specifications				

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

IN-LINE INJECTION PUMP
UNIT V

PRACTICAL TEST
JOB SHEET #7 — TIME AN IN-LINE PUMP

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ______________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Disconnected and capped all lines.	______	______
3. Connected PC stand.	______	______
4. Checked timing and adjusted if needed.	______	______
5. Activated throttle; secured in full load position.	______	______
6. Applied fuel pressure.	______	______
7. Set timing.	______	______
8. Removed pressure from PC pump.	______	______
9. Removed PC pump.	______	______
10. Torqued the drive gear.	______	______
11. Rechecked timing.	______	______
12. Reconnected all lines.	______	______
13. Started engine.	______	______
14. Checked in/put away tools and materials.	______	______
15. Cleaned the work area.	______	______
16. Used proper tools correctly.	______	______
17. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
18. Practiced safety rules throughout procedure.	______	______
19. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #7 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

	4	3	2	1
Engine started				
	4	3	2	1
Engine ran smoothly				

EVALUATOR'S COMMENTS: ____

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

IN-LINE INJECTON PUMP
UNIT V

NAME ______________________ SCORE ____________________

TEST

1. Match the terms on the right with the correct definitions.

_____a. Sends fuel at low pressure through filters to the injection pump

_____b. Machined recess forming a ring on pumping plunger

_____c. Located at right angles to the plane of the supporting surface

_____d. Spiraled, machined recess on pumping plunger

_____e. Long, narrow fuel or oil passage

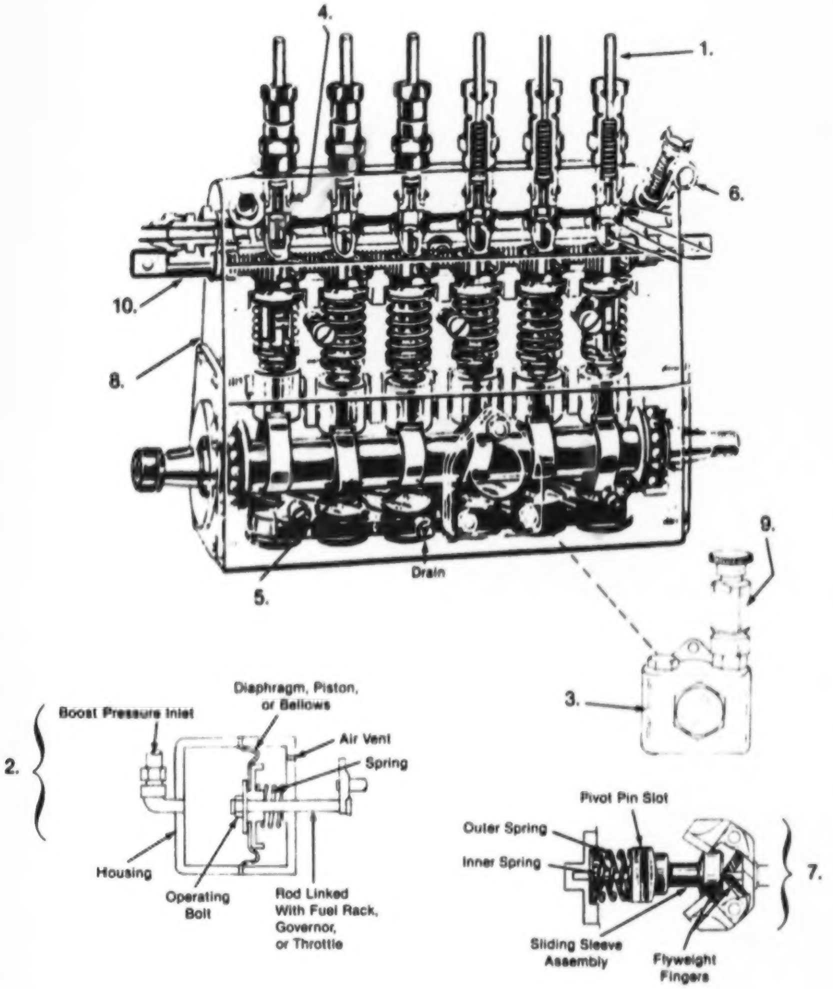
_____f. Device which limits fuel supply to engine, preventing excess smoke

_____g. Uses an individual pump for each cylinder with pumps mounted in-line

_____h. A speed-sensing device that employs centrifugal force and spring tension to govern engine speed

1. Aneroid
2. Annular groove
3. Gallery
4. Governor
5. Helix
6. In-line injection pump
7. Transfer pump
8. Vertical slot

2. Match the main parts of an in-line pump with their correct names by placing the correct numbers in the appropriate blanks.


4.
1.
6.
10.
8.
Drain
5.
9.
3.
2.
Boost Pressure Inlet
Diaphragm, Piston, or Bellows
Air Vent
Spring
Housing
Operating Bolt
Rod Linked With Fuel Rack, Governor, or Throttle
Pivot Pin Slot
Outer Spring
Inner Spring
Sliding Sleeve Assembly
Flyweight Fingers
7.

_____a. Control rack

_____b. Hand primer

_____c. Governor

_____d. Injection line

_____e. Pump housing

_____f. Aneroid

_____g. Leak-off line

_____h. Fuel transfer pump

_____i. Camshaft

_____j. Individual pumping element

TEST

3. Arrange in order the steps in which fuel flows from supply tank to delivery by placing the correct sequence numbers in the appropriate blanks.

_____a. Pumping element meters fuel at high pressure to each injection nozzle for delivery to combustion chamber.

_____b. Transfer pump forces fuel under low pressure through secondary filter and through final stage filter to each injection pumping element.

_____c. Fuel is drawn from supply tank through primary filter by fuel transfer pump.

4. State the purpose of a hand primer.

____

____

5. Select true statements concerning the purpose of a fuel transfer pump by placing an "X" beside the true statement(s).

_____a. Draws fuel from supply tank through secondary filter

_____b. Assures fuel supply to injection pumping elements

6. Select true statements concerning the operation of an injection pump by placing an "X" beside the true statement(s).

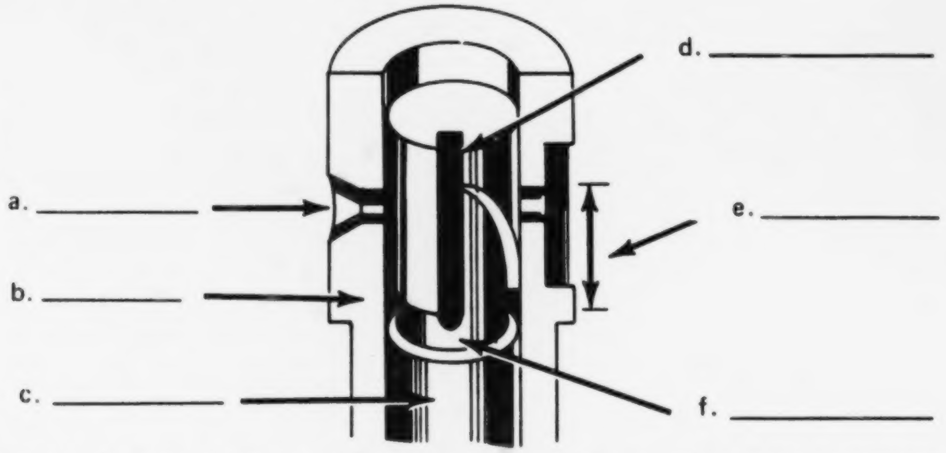
_____a. Plunger type pump has engine driven camshaft rotating at half engine speed

_____b. Roller cam followers, riding on cam lobes, operate the plungers to supply low pressure fuel through delivery valves to injection nozzles

TEST

7. Identify parts and design features of a pumping element.

7. Identify parts and design features of a pumping element.



8. Complete the following list of statements concerning the operation of the control rack and sleeve by inserting the words that best complete each statement.

   a. Governor moves rack to regulate speed of engine.

   b. The sleeve, rotated by the control rack, is fitted over the barrel and connects to the ______________________________

      ____

   c. Plunger rotation opens or closes the helix which meters ______________

      ____

9. State the purpose of a delivery valve.

____

____

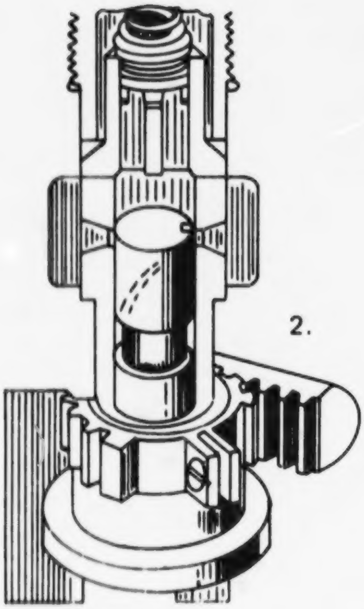
TEST

10. Identify the plunger and rack positions.

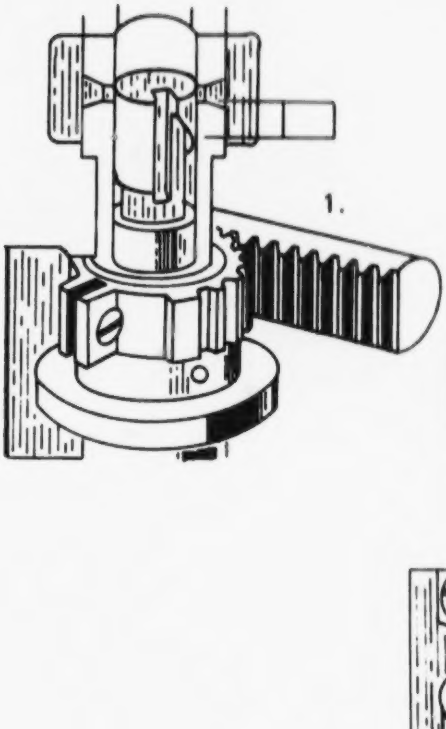
______a. No fuel delivery

______b. Partial fuel delivery

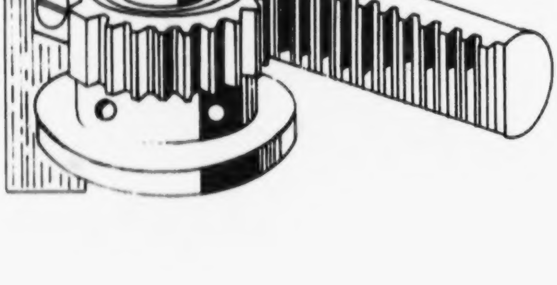
______c. Maximum fuel delivery



2.



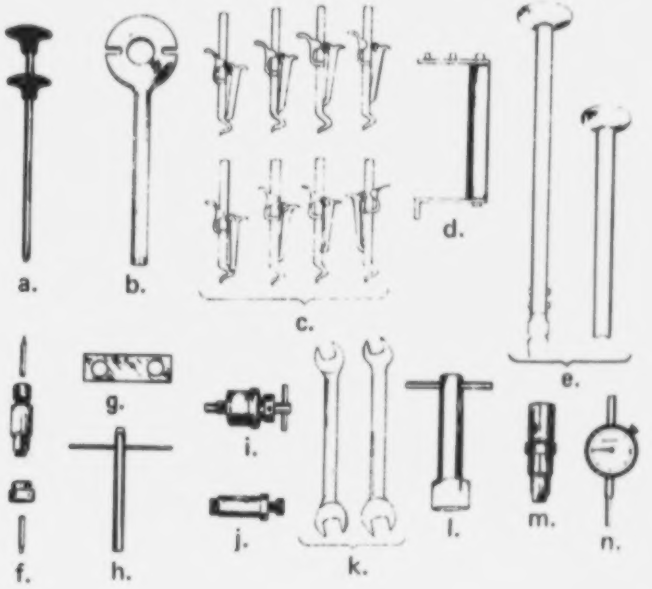
1.



3.

TEST

11. Identify typical tools used for overhauling an in-line injection pump.


a.
b.
c.
d.
e.
f.
g.
h.
i.
j.
k.
l.
m.
n.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

g. ______________________________

h. ______________________________

i. ______________________________

j. ______________________________

k. ______________________________

l. ______________________________

m. ______________________________

n. ______________________________

TEST

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

12. Demonstrate the ability to:

    a. Remove an in-line pump. (Job Sheet #1)

    b. Overhaul an in-line pump. (Job Sheet #2)

    c. Clean and inspect in-line pump components. (Job Sheet #3)

    d. Reassemble an in-line pump. (Job Sheet #4)

    e. Reassemble the R.Q.V. governor. (Job Sheet #5)

    f. Bench test an in-line pump. (Job Sheet #6)

    g. Time an in-line pump. (Job Sheet #7)

IN-LINE INJECTION PUMP
UNIT V

ANSWERS TO TEST

1. a. 7
   b. 2
   c. 8
   d. 5
   e. 3
   f. 1
   g. 6
   h. 4

2. a. 10
   b. 9
   c. 7
   d. 1
   e. 8
   f. 2
   g. 6
   h. 3
   i. 5
   j. 4

3. a. 3
   b. 2
   c. 1

4. Hand primer on fuel transfer pump can be operated by hand to pump fuel when bleeding the system.

5. b

6. a

7. a. Spill ports
   b. Barrel
   c. Plunger
   d. Vertical slot
   e. Helix
   f. Annular groove

8. b. Vanes on the plunger
   c. The quantity of fuel for delivery to cylinder

9. The delivery valve creates a sudden pressure drop in the delivery line causing the injector nozzle valve to close instantly.

10. a. 2
    b. 1
    c. 3

ANSWERS TO TEST

11. a. Remover and installer, barrel plunger
    b. Wrench, holding, drive flange
    c. Holder, tappet
    d. Fixture, pump holding
    e. Remover and installer, tappet
    f. Rack gauge holder
    g. Gauge, camshaft protrusion
    h. Wrench, governor spring adjusting
    i. Remover and installer, governor spring and adjusting screw
    j. Remover, governor flyweight damper
    k. Wrench, tappet adjusting
    l. Holder, dial indicator
    m. Remover and installer, camshaft cylindrical nut
    n. Dial indicator (inch reading)

12. Performance skills evaluated to the satisfaction of the instructor

PT FUEL SYSTEMS
UNIT VI

UNIT OBJECTIVE

After completion of this unit, the student should be able to remove, replace, and test a PT pump and injector. The student should also be able to adjust and time an injector. Competencies will be demonstrated by completing the job sheets and the unit tests with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to PT fuel systems with the correct definitions.
2. Name parts of a PT fuel system.
3. Match the main units of a PT pump assembly with the functions.
4. Select true statements concerning the operation of a PT injection system.
5. State the function of a pulsation damper.
6. Complete a list of statements concerning the operation of a mechanical governor.
7. Name types of PT injectors.
8. Match the operational steps of PT injectors with the descriptions.
9. Demonstrate the ability to:
    a. Locate a faulty Cummins injector. (Job Sheet #1)
    b. Remove and install PT (type B, C, D, and PTD Top Stop) injectors. (Job Sheet #2)

OBJECTIVE SHEET

c. Adjust an injector plunger and valves using the torque method. (Job Sheet #3)

d. Adjust an injector using the dial indicator method. (Job Sheet #4)

e. Install a PTG fuel pump, and adjust high and low engine idle. (Job Sheet #5)

f. Test and adjust a PTG fuel pump. (Job Sheet #6)

g. Time a Cummins injector. (Job Sheet #7)

PT FUEL SYSTEMS
UNIT VI

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in this unit of instruction.

(NOTE: This activity should be completed prior to the teaching of this unit.)

B. Make transparencies from the transparency masters included with this unit.

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information sheet.

F. Discuss information sheet.

(NOTE: Use the transparencies to enhance the information as needed.)

G. Provide students with job sheets.

H. Discuss and demonstrate the procedures outlined in the job sheets.

I. Integrate the following activities throughout the teaching of this unit:

1. Supply the appropriate service manual for the injector you have in your shop.

2. Obtain at least 3 types of PT pumps (PTR, PTG, AFC) for use in classroom demonstrations.

3. Obtain at least 4 types of PT injectors (type B, C, D, and PTD Top Stop) for use in classroom.

4. Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas for improvement.

J. Give test.

K. Evaluate test.

L. Reteach if necessary.

REFERENCES USED IN DEVELOPING THIS UNIT

A. Kates, Edgar J., and William E. Luck. *Diesel and High Compression Gas Engines.* 3rd ed. Chicago: American Technical Society, 1974.

B. *Service Bulletin No. 3379011-01: Injector Plunger and Valve Adjustments.* Columbus, IN: Cummins Engine Co., December, 1985.

C. *Service Bulletin No. 3379101-11: PT Fuel Pump Calibration.* Columbus, IN: Cummins Engine Co., December, 1985.

D. Toboldt, William K. *Diesel Fundamentals, Service, Repair.* South Holland, IL: Goodheart-Willcox Company, Inc., 1980.

SUGGESTED SUPPLEMENTAL RESOURCES

Texts

A. *Service Bulletin No. 3379071-02: Injectors, All Types*
Cummins Engine Company
Box 3005
Columbus, IN 47201

B. *Service Bulletin No. 983725: Calibration of PTG Pumps*
Cummins Engine Company
Box 3005
Columbus, IN 47201

C. *Service Bulletin No. 983535: Fuel Pump PT Rebuilding*
Cummins Engine Company
Box 3005
Columbus, IN 47201

D. *Service Bulletin No. 3379084-02: Fuel Pump PT Rebuilding*
Cummins Engine Company
Box 3005
Columbus, IN 47201

PT FUEL SYSTEMS
UNIT VI

INFORMATION SHEET

I. **Terms and definitions**

   A. High idle or maximum no-load speed — Engine rpm's with no-load and throttle fully open

   B. Meter — To supply in a measured amount

   C. PTG-AFC — PT pump with air fuel ratio control

   D. PT injector — Cummins injector based on pressure time system

   E. PT type G — PT fuel pump which is governor controlled

   F. PT system — Pressure time system based on principle that volume of liquid flow is proportionate to fluid pressure, time allowed to flow, and size of passage through which liquid flows

   G. PT type R — PT fuel pump which is pressure regulated

   H. Rated speed — Engine rpm's under full load

II. **Main parts of PT fuel system** (Transparency 1)

   A. Fuel pump

   B. Supply lines, drain lines, and passages

   C. Injectors

III. **Functions of units of PT pump assembly** (Transparency 2)

   A. Gear pump — Draws fuel from supply tank forcing it through the pump filter screen into the pressure regulator valve

   B. Pressure regulator — Limits pressure of fuel to injectors

   C. Throttle — Provides manual control of fuel flow to injector under all conditions in operating range

   D. Governor assembly — Controls flow of fuel from idle to maximum governor speed

INFORMATION SHEET

IV. **Operation of a PT injection system**

A. Gear type fuel pump delivers fuel through a restricting throttle to the governor.

B. From the governor, the fuel goes to a manifold which feeds cam-operated injectors in the cylinder head.

C. Injector raises pressure to produce a good spray and times the start of injection.

V. **Function of pulsation damper — The damper contains a steel diaphragm which absorbs pulsations and smooths fuel flow through system.** (Transparency 2)

(NOTE: The pulsation damper, mounted on gear pump, performs the same function on both type G and type R fuel pumps.)

VI. **Operation of mechanical governor** (Transparency 2)

A. Between idle and maximum speed, fuel flows through the governor to the injector in accordance with engine requirements as controlled by the throttle.

B. When engine reaches governed speed, the governor weights move the governor plungers so fuel passage to the injectors is reduced.

(NOTE: At the same time another passage opens and dumps the fuel back into the main pump body. The engine speed is controlled and limited regardless of the position of the throttle.)

C. Fuel leaving the governor flows through the shut down valve, inlet supply lines, and onto the injectors.

VII. **Types of PT injectors** (Transparency 3)

A. PTD-Top Stop

B. PTB, C, D

VIII. **Operational steps of PT injectors** (Transparency 4)

A. Metering

1. Fuel enters the injector at fuel inlet

(NOTE: Pressure is determined by throttle and/or governor.)

2. Balance orifice controls quantity of fuel that enters the injector cup.

(NOTE: Pressure is determined by the fuel pump and the time interval during which the hole supplying fuel is uncovered by the injector plunger. This is controlled by cam profile.)

INFORMATION SHEET

B. Injection

1. Downward plunger movement cuts off fuel entry into injector cup.

2. Continued downward movement forces fuel from injector cup through the spray orifices into combustion chamber.

   (NOTE: High pressures allow for almost complete burning of fuel spray.)

C. Cooling

1. While plunger is down, fuel passes through upper hole around undercut in plunger through return passages to the fuel tank.

2. Plunger remains seated after injection.

   (NOTE: Fuel flows through the injector cooling it and warming tank fuel through this stage. Plunger rises back to metering operation.)

D. Air fuel ratio control (Transparencies 5 and 6)

(NOTE: Air fuel ratio control valve is built into the PTG pump.)

1. The AFC is made to replace the PTG pump and aneroid on turbocharged engines.

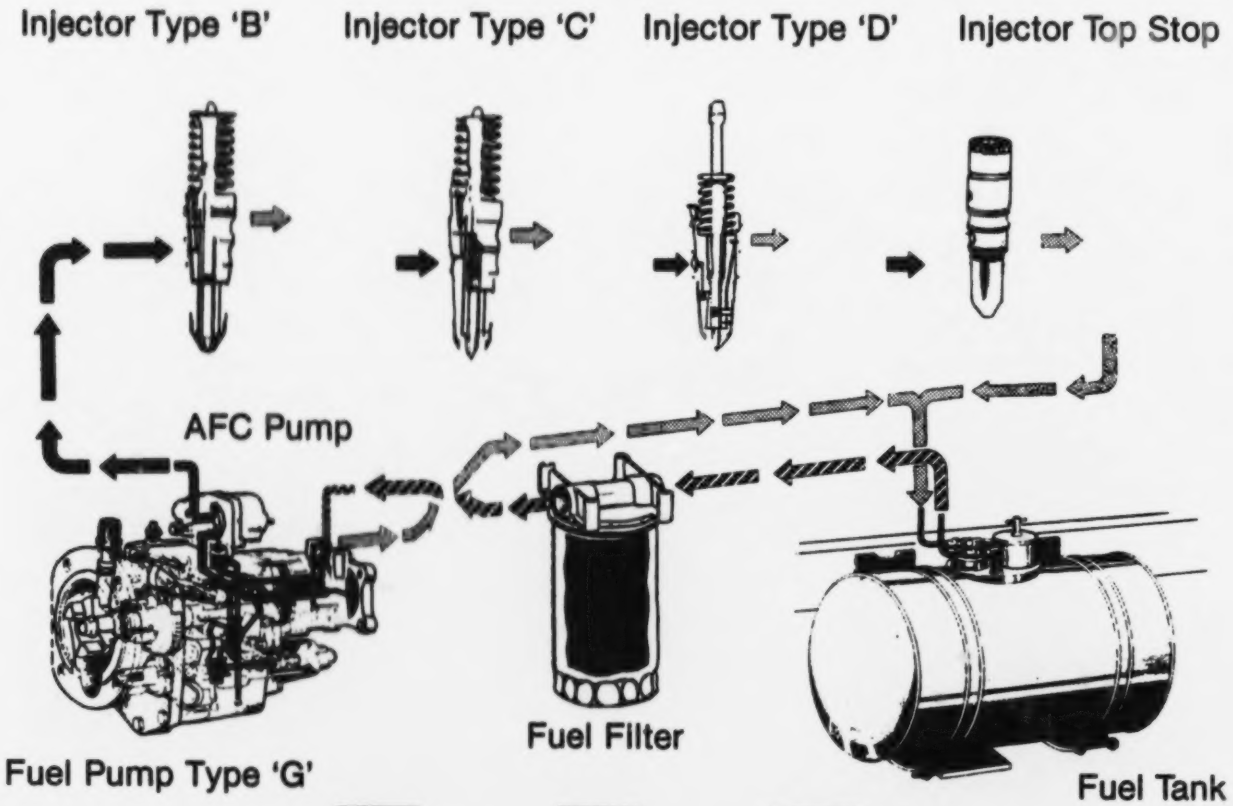
2. The AFC limits fuel pressure and flow restriction.

3. The AFC gives the correct air fuel delivery rate to the engine during acceleration.

   (NOTE: Air fuel ratio is controlled through air pressure in the intake manifold. This is turbo pressure plus atmospheric pressure.)

Main Parts of PT Fuel System

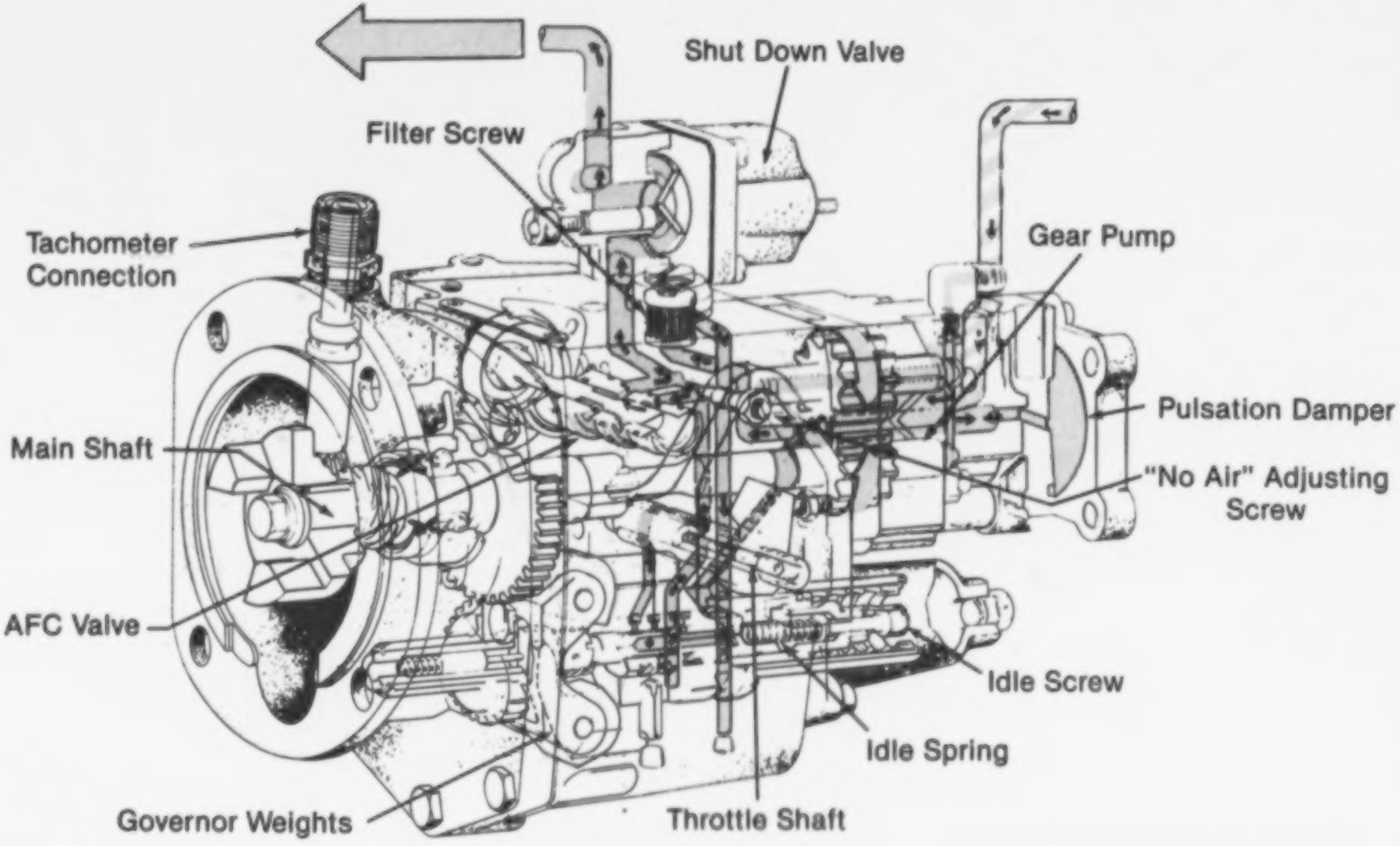
Cummins


Injector Type 'B'
Injector Type 'C'
Injector Type 'D'
Injector Top Stop
AFC Pump
Fuel Pump Type 'G'
Fuel Filter
Fuel Tank

■ Fuel Supply ▨ Fuel Suction ▒ Fuel Return

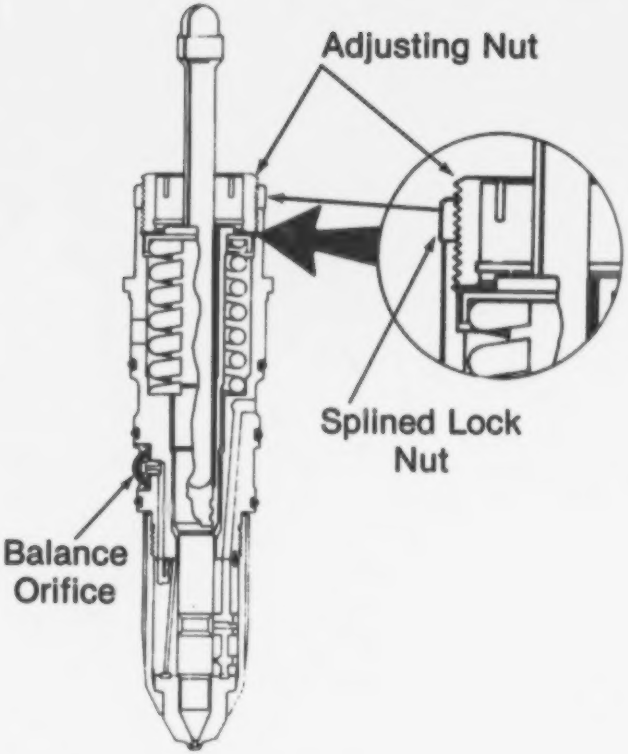
Courtesy of Cummins Engine Co., Inc.

PTG — AFC Pump

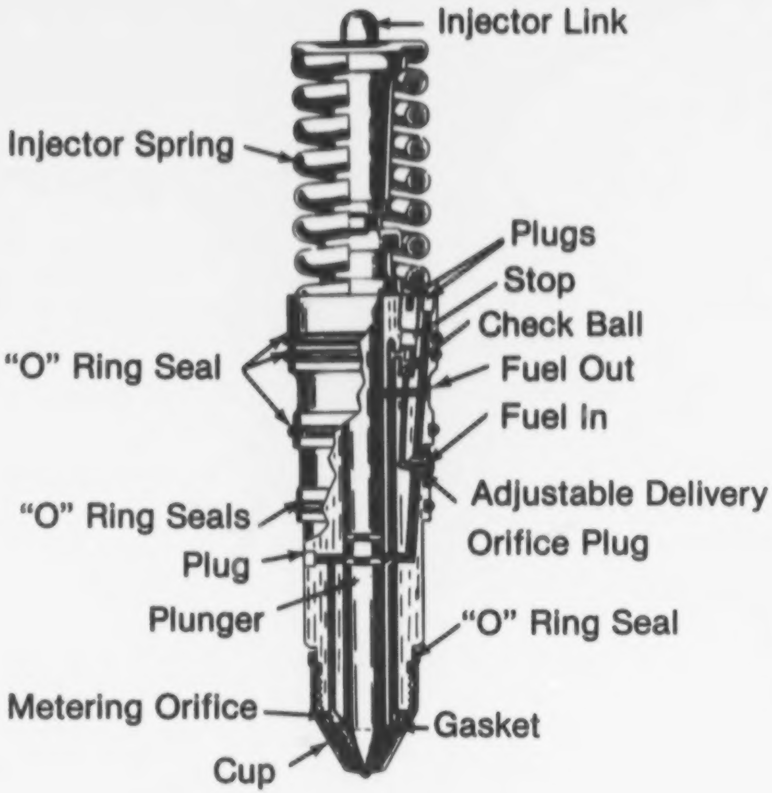

Shut Down Valve
Filter Screw
Tachometer Connection
Gear Pump
Pulsation Damper
Main Shaft
"No Air" Adjusting Screw
AFC Valve
Idle Screw
Idle Spring
Governor Weights
Throttle Shaft

Courtesy of Cummins Engine Co., Inc.

Types of Injectors


Adjusting Nut
Splined Lock Nut
Balance Orifice

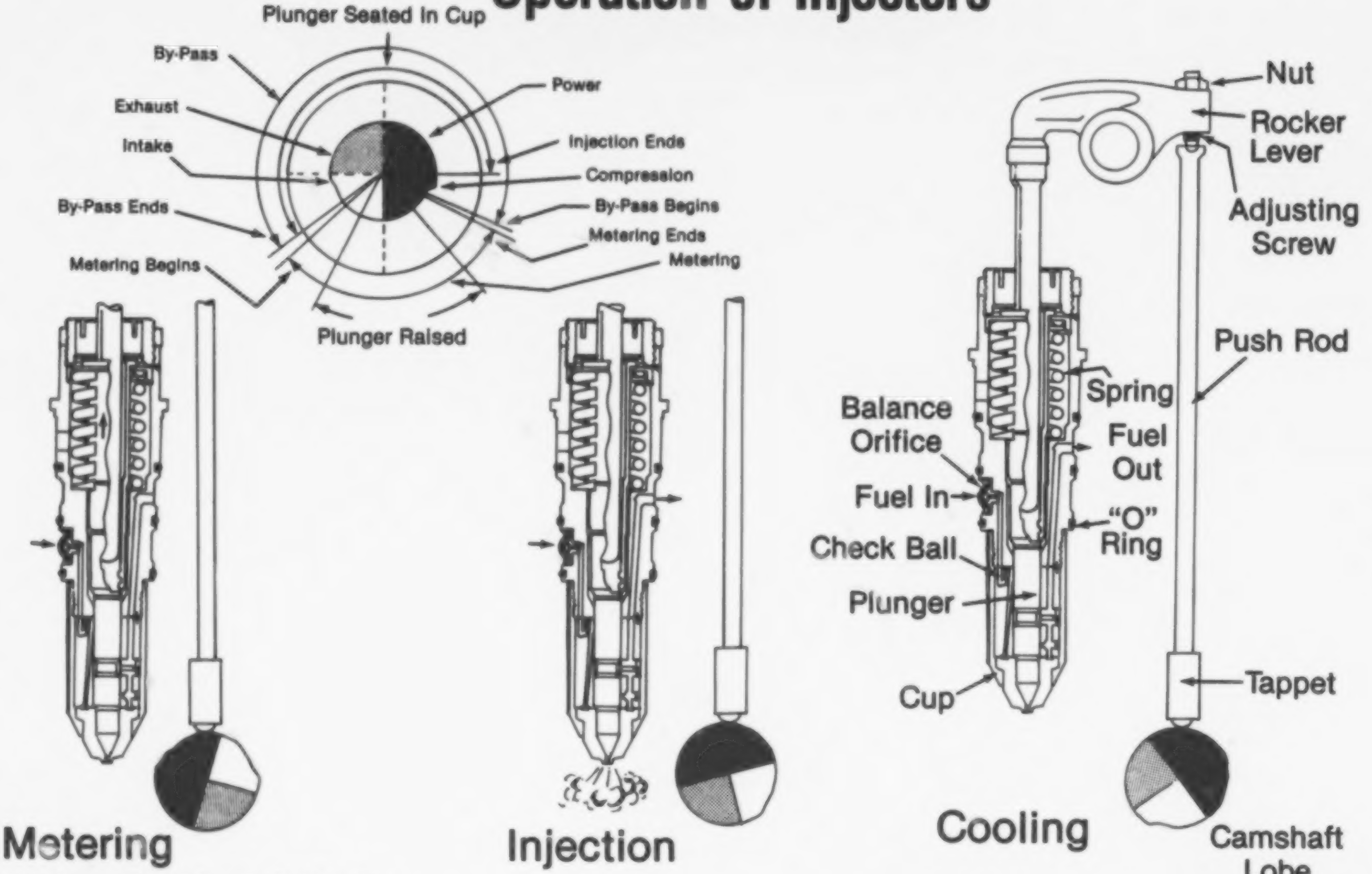
Top Stop Injector


Injector Link
Injector Spring
Plugs
Stop
Check Ball
"O" Ring Seal
Fuel Out
Fuel In
Adjustable Delivery Orifice Plug
"O" Ring Seals
Plug
Plunger
"O" Ring Seal
Metering Orifice
Gasket
Cup

Cylindrical Injector

Courtesy of Cummins Engine Co., Inc.

Operation of Injectors


Plunger Seated In Cup
By-Pass
Power
Exhaust
Intake
Injection Ends
Compression
By-Pass Ends
By-Pass Begins
Metering Ends
Metering Begins
Metering
Plunger Raised
Nut
Rocker Lever
Adjusting Screw
Push Rod
Spring
Balance Orifice
Fuel Out
Fuel In
"O" Ring
Check Ball
Plunger
Cup
Tappet
Camshaft Lobe

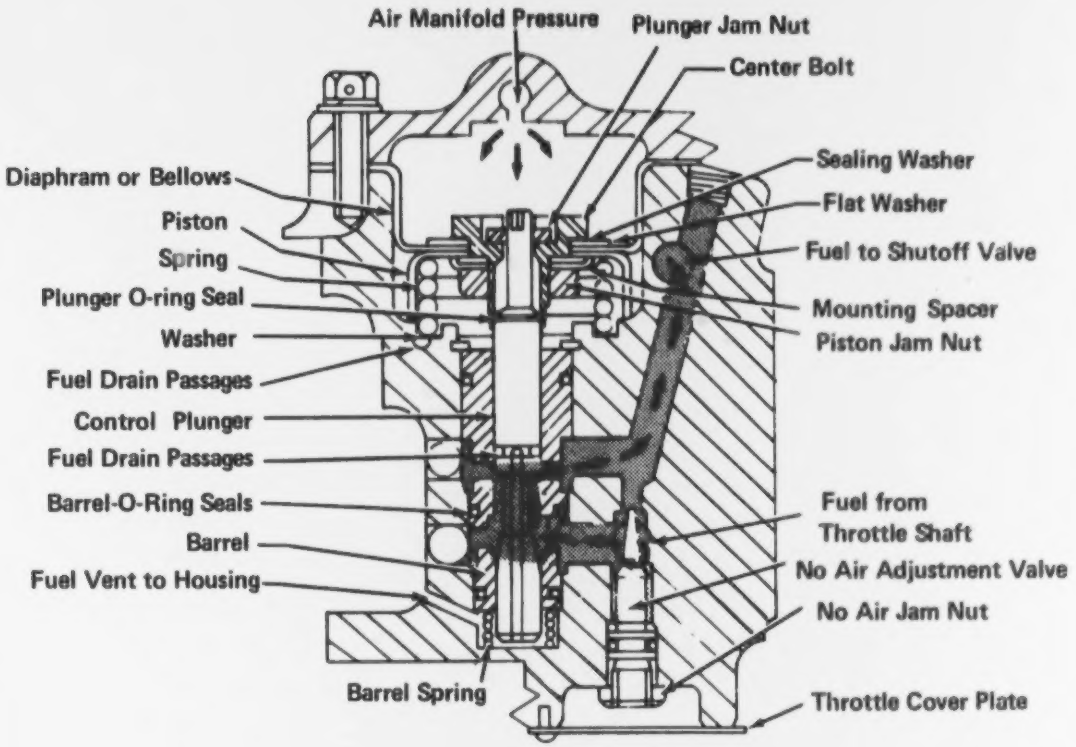
Metering

Injection

Cooling

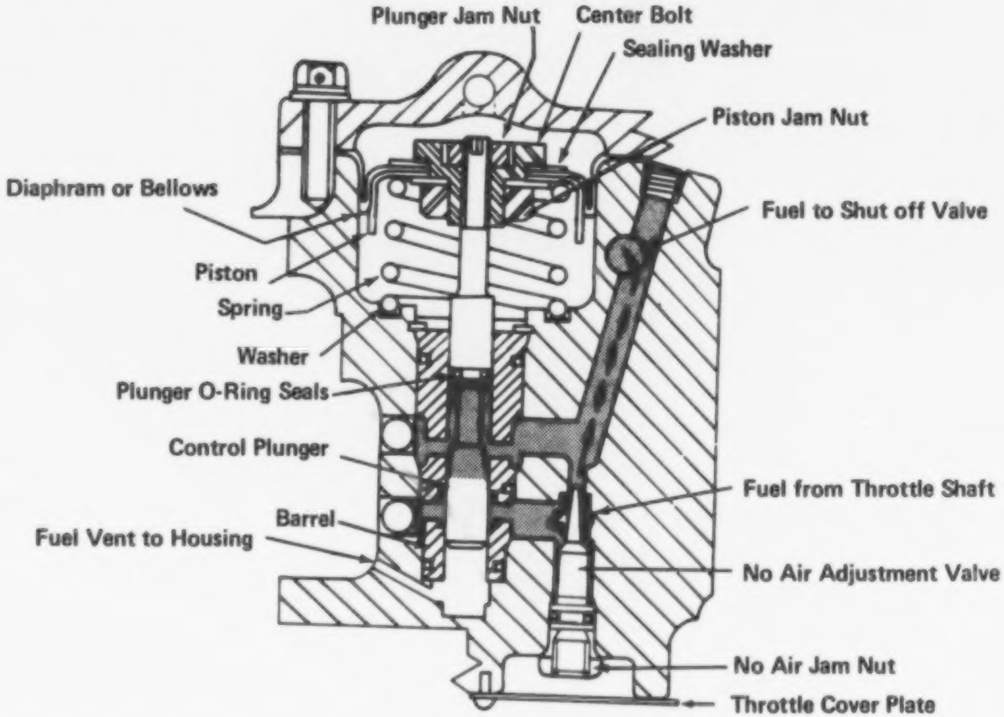
Courtesy of Cummins Engine Co., Inc.

AFC in the "Full Air" Position


Air Manifold Pressure
Plunger Jam Nut
Center Bolt
Sealing Washer
Flat Washer
Fuel to Shutoff Valve
Mounting Spacer
Piston Jam Nut
Diaphram or Bellows
Piston
Spring
Plunger O-ring Seal
Washer
Fuel Drain Passages
Control Plunger
Fuel Drain Passages
Barrel-O-Ring Seals
Barrel
Fuel Vent to Housing
Barrel Spring
Fuel from Throttle Shaft
No Air Adjustment Valve
No Air Jam Nut
Throttle Cover Plate

New Design with the AFC Control Plunger in the "Full Air" Position. Used When the ASA is in the Fuel.

AFC in the "No Air" Position


Plunger Jam Nut
Center Bolt
Sealing Washer
Piston Jam Nut
Diaphram or Bellows
Fuel to Shut off Valve
Piston
Spring
Washer
Plunger O-Ring Seals
Control Plunger
Fuel from Throttle Shaft
Barrel
Fuel Vent to Housing
No Air Adjustment Valve
No Air Jam Nut
Throttle Cover Plate

AFC Top View-Cross Section with the Control Plunger in the "No Air" Position. Used When the ASA Was in the AFC Cover.

PT FUEL SYSTEMS
UNIT VI

JOB SHEET #1 — LOCATE A FAULTY CUMMINS INJECTOR

A. Tools and materials

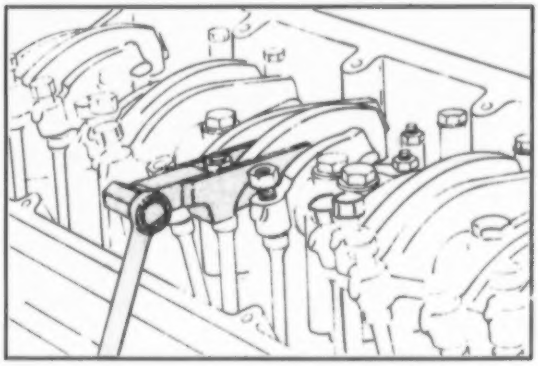
1. Basic hand tools
2. Appropriate service manual
3. Shop towels
4. Safety glasses
5. Injector rocker lever actuator

B. Procedure

(CAUTION: Follow all shop safety procedures.)

1. Start engine and bring to operating temperature.
2. Shut off engine.
3. Remove valve covers.
4. Start engine.
5. Hold injector plunger down with injector rocker lever actuator. (Figure 1)

FIGURE 1



JOB SHEET #1

6. Listen for a change in engine speed.

   a. If sound does not change and rpm does not drop, the injector is bad.

   b. A change in sound and rpm indicates a good injector.

   (NOTE: A weak injector will change slightly, but not as much. Compare with the other cylinders.)

PT FUEL SYSTEMS
UNIT VI

JOB SHEET #2 — REMOVE AND INSTALL PT (TYPE B, C, D, AND PTD TOP STOP) INJECTORS

A. Tools and materials

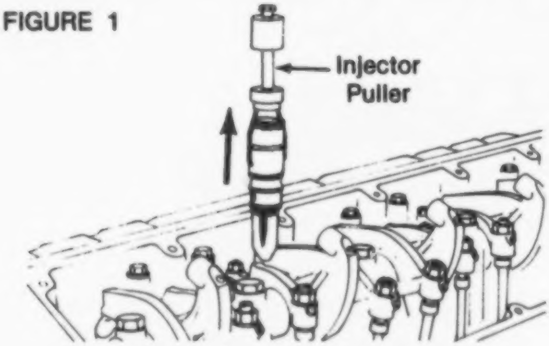
1. Basic hand tool set
2. Appropriate service manual
3. Torque wrench
4. Oil can, hand type
5. Shop towels
6. Safety glasses

B. Procedure

(CAUTION: Follow all shop safety procedures.)

1. Remove injectors (type B and C).
   a. Remove hold-down capscrews.
   b. Remove injector with heel bar or Cummins injector puller. (Figure 1)

FIGURE 1



Courtesy of Cummins Engine Co., Inc.

   c. Place injectors in rack for protection.
   d. Tag and number injectors by cylinder from which removed.

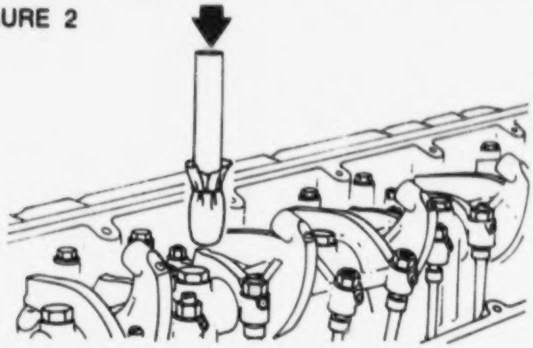
(CAUTION: Do not damage injectors tips.)

JOB SHEET #2

2. Install injectors (type B and C).

   a. Clean injector sleeve with cloth wrapped around wooden stick. (Figure 2)

   FIGURE 2

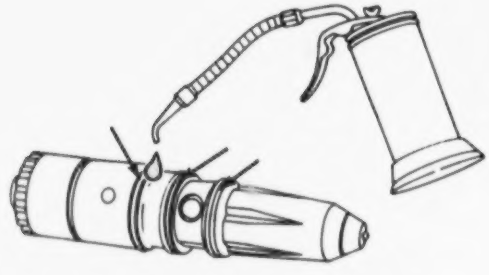


Courtesy of Cummins Engine Co., Inc.

   b. Lubricate the injector body O-rings with clean S.A.E. 20 or 30 weight lubricating oil.

   (NOTE: The O-rings should receive a fresh coat of oil each time injectors are installed in head. See Figure 3.)

   FIGURE 3

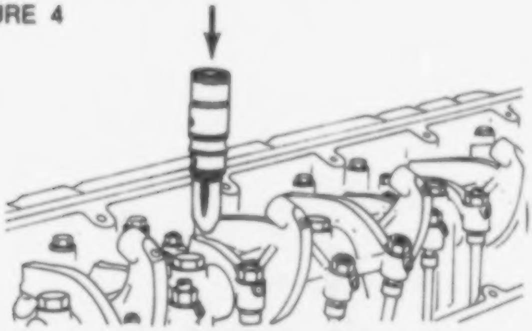


Courtesy of Cummins Engine Co., Inc.

JOB SHEET #2

c. Start the injector into bore, guiding by hand until injector is aligned in bore and not binding in any manner. (Figure 4)

FIGURE 4



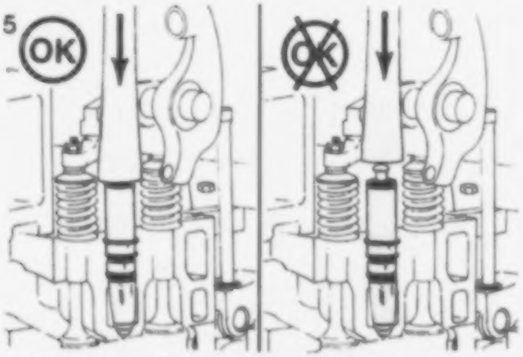
Courtesy of Cummins Engine Co., Inc.

(NOTE: To install injectors on V-12 engines, stand either on right bank side or left bank side of engine. On H or NH engines, install injectors from fuel pump side of engine. Injectors are to be placed with ball check retainer plug (screen) to exhaust manifold side.)

d. Place plastic hammer handle butt on top of injector plunger body and "seat" injector by giving a quick, hard push on the hammer.

(NOTE: A "snap" should be heard and felt as the cup seats in the copper sleeve. See Figure 5.)

FIGURE 5



Courtesy of Cummins Engine Co., Inc.

e. Place hold-down plate over injector body with counterbore up.

f. Position half-collet locking clamp in injector body groove.

g. Start hold-down capscrews, but do not tighten.

(NOTE: Be sure the two projecting radii do not drop in drilled holes atop injector.)

JOB SHEET #2

h. Place injector spring on hold-down plate with close coil down.

   (NOTE: Spring must seat on hold-down plate; if spring seats on locking clamp, incorrect injector adjustment will result, causing push tube and camshaft damage.)

i. Hold injector spring in position and carefully insert injector plunger.

   (NOTE: On V-12 engines only, position plunger in injector bore with class mark on the plunger midway between inlet and drain ports of injector; the inlet port is below the ball retainer plug. This will provide the same operating position in which the injector was calibrated.)

j. Look up torque procedure for V-12 engines only.

   1) Make sure injector is positioned correctly in head.

   2) Tighten one capscrew (use Nylok® capscrews) until clamp contacts head snugly; then back out one complete turn.

   3) Tighten other capscrew to a torque of 48 to 60 in-lb (5 to 7 N. m).

   4) Tighten first capscrew to 84 to 96 in-lb (9 to 11 N. m).

   5) Tighten second capscrew to 84 to 96 in-lb (9 to 11 N. m).

   6) Check the plunger to see if it is free.

   7) Loosen clamp and retorque if the plunger is not free.

      (NOTE: On H and NH engines, position plunger in injector bore with class mark on the plunger toward rear of engine. This will provide the same operating position in which the injector was calibrated.)

k. Torque hold-down capscrews in alternate steps to 132 to 144 in-lb (15 to 16 N. m).

3. Remove and install PT (type D) injectors.

   a. Remove injector hold-down plate or yoke.

      (NOTE: On some engines, special tools are needed to remove injectors; consult appropriate service manual.)

      1) Use an injector puller on NH, NT, and NTA series engines.

      2) Use a right angle roll bar or pinch bar to pry injectors from head in "V" series engines.

         (NOTE: When prying up, be certain to keep the plunger and/or injector from jumping out of the head and landing on the floor.)

JOB SHEET #2

b. Remove all carbon from injector copper sleeves.

(NOTE: Do not use anything metal to scrape the sleeves; use a wooden stick with a clean cloth wrapped around the end.)

c. Lubricate the O-rings with 20 to 30 weight lube oil; **do not use Lubriplate.®**

d. Start injector into bore, guiding by hand until aligned in bore and not binding.

(NOTE: Install with screen to the exhaust side of the engine.)

e. Place a clean blunt object on injector body and "seat" injector by giving a quick, hard push.

f. Listen for the snap as cup seats in copper sleeve.

(NOTE: Do not use a wooden hammer handle or similar tool to install injectors. Dirt or splinters from the handle may drop into plunger link seat causing early failure of link or plunger socket. If injector is not completely seated, the O-rings may be damaged if pulled down with the mounting capscrews.)

g. Install hold-down plates or yokes, lockwashers, and capscrews.

(NOTE: Be certain plates or yokes do not contact crosshead stems.)

h. Torque NH, NT, and KT capscrews in alternate steps to 132 to 144 in-lb (15 to 16 N. m).

   1) Use self-locking (Nylok®) capscrews on V-12 engines and torque alternately to 132 to 144 in-lb (15 to 16 N. m).

   2) Torque V-6-140, V-8-185, V-378, V-504, V-555, V-8-265 and V-903 capscrews to 360 to 420 in-lb (41 to 47 N. m).

i. Test injector plunger for movement after torquing hold-down capscrews. If plunger is not free, loosen and retorque capscrews.

PT FUEL SYSTEMS
UNIT VI

JOB SHEET #3 — ADJUST AN INJECTOR PLUNGER AND VALVES USING THE TORQUE METHOD

A. Tools and materials

1. NH, NT, NTA 855, C.I.D. series Cummins engine

   (NOTE: For specific installation and models, refer to the engine manufacturer's specifications.)

2. Appropriate service manual
3. Basic hand tool set
4. Inch-pounds torque wrench
5. Foot-pounds torque wrench
6. Feeler gauge
7. Shop towels
8. Safety glasses

B. Procedure

(CAUTION: Follow all shop safety procedures.)

(NOTE: Retorque injector hold-down clamp capscrews to manufacturer's specifications before adjusting injectors or head on rebuilt engines.)

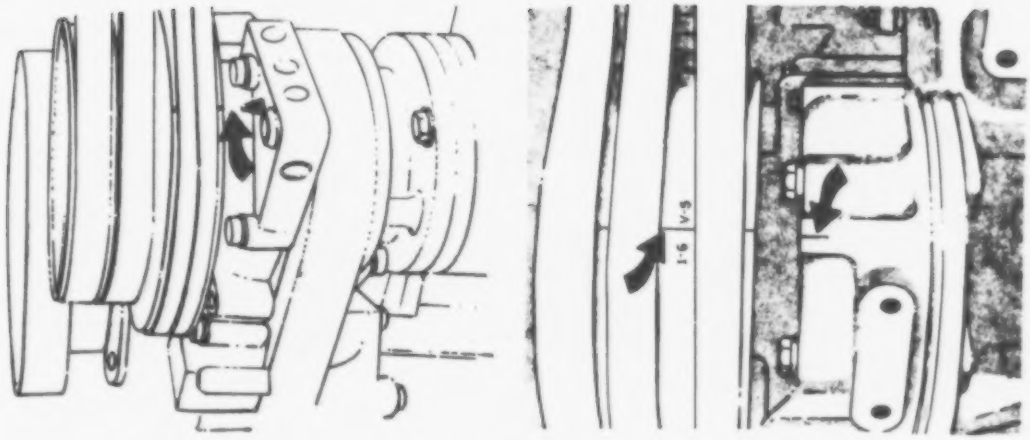
1. Position valves and mark alignment.

   a. Turn crankshaft in direction of rotation until #1-6 "VS" mark appears on the accessory drive pulley. (Figure 1)

      (NOTE: Some models may have "A" or 1-6 "VS" marked on damper.)

JOB SHEET #3

FIGURE 1



Courtesy of Cummins Engine Co., Inc.

(NOTE: In this position, both intake and exhaust valves must be closed for cylinder #1; if not, advance crankshaft one revolution. See Figure 1.)

b. Adjust injector plunger, then crossheads and valves of first cylinder as explained in the following steps.

c. Turn crankshaft in direction of rotation to next "VS" mark corresponding to firing order of engine and corresponding cylinder will be ready for adjustment. (See service manual.)

d. Continue turning crankshaft in direction of rotation and making adjustments until all injectors and valves have been correctly adjusted.

(NOTE: Two complete revolutions of crankshaft are needed to set all injector plungers and valves. Injector and valves can be adjusted for only one cylinder at any one "VS" setting.)

2. Adjust crosshead.

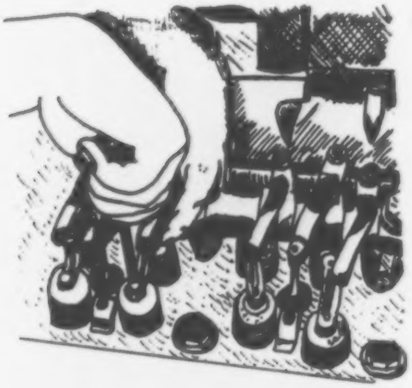
   a. Loosen valve crosshead adjusting screw locknut and back off screw one turn.

   b. Use light finger pressure at rocker lever contact surface to hold crosshead in contact with valve stem (without adjusting screw).

JOB SHEET #3

c. Adjust crosshead adjusting screw according to engine manufacturer's specifications. (Figure 2)

FIGURE 2



d. Hold adjusting screw in this position, and torque locknut to values specified in appropriate service manual. (Table 1)

Table 1: Crosshead Locknut Torque

Without ST-669	With ST-669
25 to 30 ft-lbs (34 to 38 N. m)	22 to 26 ft-lbs (30 to 35 N. m)

3. Adjust injector plunger.

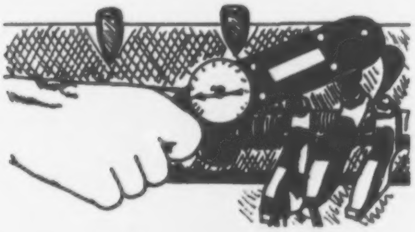
   a. Turn adjusting screw down until plunger contacts cup, and advance an additional 15° to squeeze oil from cup.

   b. Loosen adjusting screw one turn.

JOB SHEET #3

c. Using a torque wrench calibrated in in-lbs and a screwdriver adapter, tighten the adjusting screw to values shown in Table 1 for cold setting, and tighten the locknut to manufacturer's specification figures. (Figure 3)

FIGURE 3

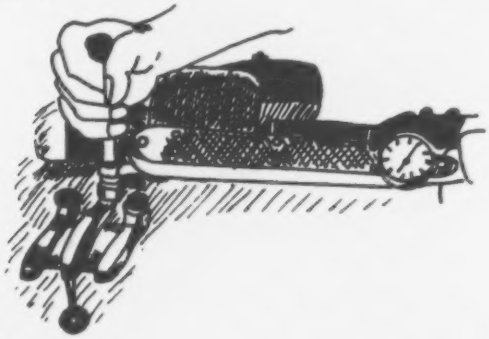


(NOTE: Some engines use different hot and cold torque settings.)

d. Hold injector adjusting screw, and tighten injector adjusting screw locknut to value specified in appropriate service manual. (Figure 4)

(NOTE: Adjust plunger before adjusting valves for accurate settings.)

FIGURE 4



4. Adjust valves.

(NOTE: The same crankshaft position used in adjusting injectors is used for setting intake and exhaust valves when using torque method.)

a. Loosen locknut and back off adjusting screw.

b. Insert feeler gauge between rocker lever and top of crosshead.

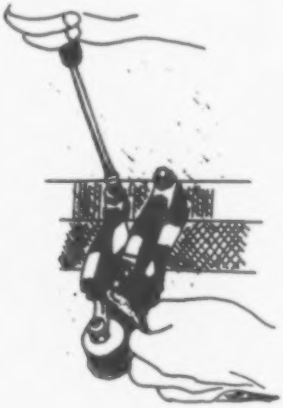
(NOTE: Consult appropriate service manual for exact specifications.)

JOB SHEET #3

c. Turn screw down until lever just touches gauge, and lock adjusting screw in this position with locknut. (Figure 5)

d. Torque locknut to values indicated in service manual.

FIGURE 5



PT FUEL SYSTEMS
UNIT VI

JOB SHEET #4 — ADJUST AN INJECTOR USING THE DIAL INDICATOR METHOD

A. Tools and materials

1. Basic hand tool set
2. Appropriate service manual
3. Typical tool #ST-1170 indicator support
4. Typical tool #ST-1193 rocker lever actuator
5. Clean shop towels
6. Safety glasses

B. Procedure

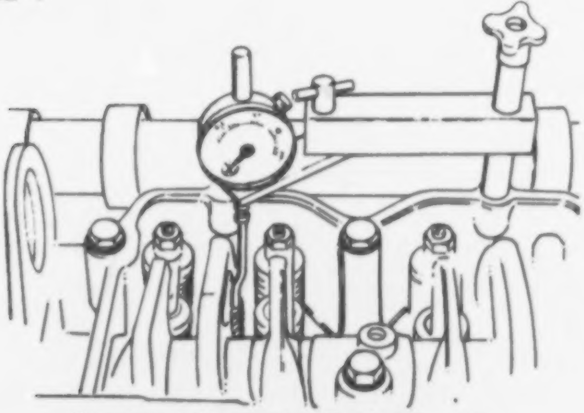
(CAUTION: Follow all shop safety procedures.)

1. Pull compression release lever back while barring engine.
2. Bar engine until "A" or 1-6 "VS" mark on pulley is aligned with pointer on gear case cover.

   (NOTE: In this position, both valve rocker levers for cylinder #5 must be free with valves closed. Injector plunger for cylinder #3 must be at top of travel; if not, bar the engine 360 degrees and re-align marks with pointer.)

3. Bottom plunger, with rocker lever actuator to squeeze oil from cup.
4. Set up ST-1170 (Figure 1) indicator support with indicator extension on injector plunger top at #3 cylinder.

   FIGURE 1

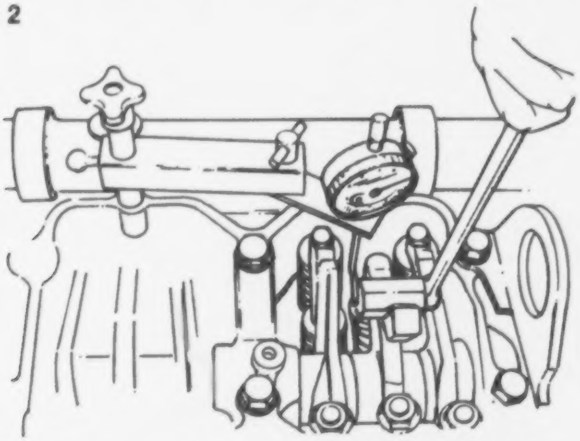


Courtesy of Cummins Engine Co., Inc.

JOB SHEET #4

5. Using the ST-1193 rocker lever actuator (Figure 2), bar the lever toward injector until plunger is bottomed; allow the injector plunger to rise. Bottom again; set indicator at zero, and check extension contact with plunger top.

FIGURE 2



(NOTE: Make sure wrench does not strike gauge face.)

6. Turn adjusting screw until adjustment value is obtained. (Table 1)

Table 1

Oil Temp.	Injector Plunger Travel	Valve Clearance	
		Intake	Exhaust
Aluminum Rocker Housing			
Cold	0.170 ± 0.001 [4.32 ± 0.03]	0.011 [0.28]	0.023 [0.58]
Hot	0.170 ± 0.001 [4.32 ± 0.03]	0.011 [0.28]	0.023 [0.58]
Cast Iron Rocker Housing			
Cold	0.175 ± 0.001 [4.45 ± 0.03]	0.013 [0.33]	0.025 [0.64]
Hot	0.170 ± 0.001 [4.32 ± 0.03]	0.011 [0.28]	0.023 [0.58]
NTE-855 (European Big Cam Only)			
	0.225 [5.72]	0.011 [0.28]	0.023 [0.58]
NT-855 (Australian Big Cam Only)			
	0.228 [5.79]	0.011 [0.28]	0.023 [0.58]

(NOTE: This is a typical setting; check appropriate service manual for exact specifications.)

JOB SHEET #4

7. Bottom the plunger again and release the lever; indicator must show travel as indicated.

   (NOTE: Release slowly to prevent damage to indicator.)

8. Tighten locknut to 480 to 540 in-lbs (54 to 61 N. m).

PT FUEL SYSTEMS
UNIT VI

JOB SHEET #5 — INSTALL A PTG FUEL PUMP, AND ADJUST HIGH AND LOW ENGINE IDLE

A. Tools and materials

1. Basic hand tool set
2. Appropriate service manual
3. Cummins engine using PTR fuel pump
4. PTR fuel pump properly calibrated
5. Hand tachometer
6. Idle adjusting tool
7. Shop towels
8. Safety glasses

B. Procedure

(CAUTION: Follow all shop safety procedures.)

1. Install pump.

   (NOTE: Injectors and valves should be set to specifications, and engine warmed to operating temperature.)

   a. Install the fuel pump to accessory drive or to compressor with new gasket and proper rubber buffer, nylon buffer, or spline coupling and tighten securely.

   b. Squirt some clean lube oil into gear pump inlet hole.

      (NOTE: This aids gear pump fuel pick-up.)

   c. Connect the fuel pump copper line from the pump shut-off valve to the fuel manifold.

      (NOTE: The throttle lever linkage should not be connected to the throttle lever, thus leaving the throttle free for pump adjustments.)

   d. Install tachometer to fuel pump tachometer drive shaft connection or use hand tachometer.

   e. Connect the shut-off valve electrical connections properly, leaving the manual control button in a closed position (screwed out).

   f. Connect pump drain line to housing.

JOB SHEET #5

2. Set governor.

   a. Set idle speed.

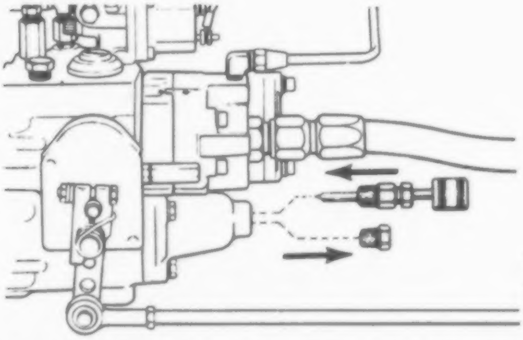
      1) Operate engine a sufficient period of time to purge air from the fuel system and to bring engine up to operating temperature (at least 165°F, oil temperature); stop engine.

      2) Remove pipe plug from spring pack cover.

      3) Install idle adjusting tool. (Figure 1)

      (NOTE: Run engine at high idle before adjusting to remove air from pump.)

FIGURE 1

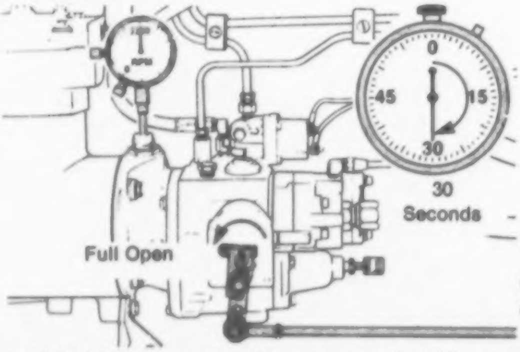


Courtesy of
Cummins Engine Co., Inc.

      4) Operate engine a sufficient period of time to purge all air from the fuel system after idle adjusting tool is installed in spring pack cover. (Figure 2)

      5) Turn idle adjusting screw in to increase or out to decrease the speed. (Figure 2)

FIGURE 2



Courtesy of
Cummins Engine Co., Inc.

(NOTE: The idle adjusting screw is held in position by a spring clip. Consult appropriate service manual for exact idle speeds.)

JOB SHEET #5

6) Remove idle adjusting tool, and replace pipe plug when idle speed is correct.

(NOTE: On the mechanical variable speed governor fuel pump, the maximum and idle adjusting screws are located on governor's cover; adjust idle by loosening rear idle adjusting screw locknut. Turn adjusting screw in or out to get speed required. Tighten adjusting screw locknut immediately after adjustment to prevent air entrapment.)

b. Set rated speed.

(NOTE: The engine should be "loaded" on an engine or chassis dynamometer to perform this check. Normally, this adjustment is made on the fuel pump test stand as the fuel pump is calibrated and does not need to be changed on the engine.)

c. Set engine hi-idle or maximum no-load speed.

(NOTE: This check should not be used to test or make governor speed adjustments. If the hi-idle speed is significantly greater than specifications, the governor assembly should be examined for malfunction or improper parts.)

PT FUEL SYSTEMS
UNIT VI

JOB SHEET #6 — TEST AND ADJUST A PTG FUEL PUMP

(NOTE: The job sheet detailed here is general and requires the use of test stand manual, pump specification sheet, and the appropriate engine service manual.)

A. Tools and materials

1. Basic hand tool set
2. Appropriate service manual
3. Test stand and adapters
4. Test stand manual
5. Pump special tools
6. PTG fuel pump
7. Pump specification sheet
8. Shop towels (lint-free)
9. Safety glasses

B. Procedure

(CAUTION: Follow all shop safety procedures.)

1. Clean pump exterior thoroughly.
2. Drain all fuel from pump and fill with pump stand oil.
3. Mount pump as described in pump mounting section of manual.

   (NOTE: Run all tests with fuel temperature at 90°F.)
4. Perform the test for pump run-in.
   - a. Determine pump rotation with stand in high range.
   - b. Open pump shutdown valve, manifold valve, and suction valve on pump.
   - c. Close idle valve and bypass valve on pump discharge line.
   - d. Turn on pump stand and run up to 500 rpm for pump to pick up prime.

JOB SHEET #6

e. Run pump to rated speed for 5 minutes to seat bearings, flush pump, and purge air.

f. Check for air in flow meter.

5. Perform the test on the gear pump section by operating test stand at 500 rpm and closing valve to 18" vacuum.

6. Perform the test for pump suction.

Obtain instructor's initials here ____________ before proceeding to next step.

a. Turn stand to 100 rpm below rated speed.

b. Adjust suction valve to 8" vacuum for remainder of tests.

7. Perform the test for total fuel flow.

a. Open manifold valve.

b. Close idle and bypass valves.

c. Set suction valve to 8" vacuum.

d. Raise test stand speed to PTG pump rated speed given on calibration sheet.

e. Adjust manifold valve until flow meter float indicates the flow specified under "flowmeter-lb. @ rpm" on the calibration sheet.

8. Perform the test for governor cut-off speed.

a. Place throttle in full fuel position.

b. Increase test stand speed to a point where pressure begins to drop, and check pump speed which should be within limits for "Governor Cut-Off RPM" on calibration sheet.

c. Add shims on high speed governor spring if speed is outside limits.

d. Remove shims to lower speed.

(NOTE: Each .001" of shim will change 2 rpm.)

e. After adjusting "Governor Cut-Off RPM," raise stand speed until pressure gauge drops to 40 psi or the specified pressure under "Governor Setting PSI-RPM" in specification sheet.

(NOTE: If more than 10-15 rpm higher, a change in governor barrel and plunger may be needed.)

JOB SHEET #6

9. Perform the test for throttle leakage.

    a. Operate a test stand at rated speed and flow.

    b. Hold throttle in idle position with throttle spring.

    c. Open bypass valve and close manifold valve.

    d. Place "graduate" under bypass tube and collect fuel for 30 seconds.

    e. Compare doubled amount to specification sheet, and adjust front screw to required amount.

    (NOTE: If leakage cannot be reduced, excess wear to throttle shaft is indicated.)

    f. Lock screw when setting is correct.

10. Perform the test for idle fuel pressure.

    a. Reduce test stand speed to 500 rpm or speed stated on specification sheet.

    b. Open idle valve and close manifold and bypass valve.

    c. Hold throttle in idle position.

    d. Note reading on pressure gauge.

    e. Adjust idle screw in spring pack cover to correct pressure.

    (NOTE: Screw in to increase and out to decrease pressure.)

    f. Purge air after each setting.

    Obtain instructor's initials here ______________ before proceeding to next step.

11. Perform the test for manifold fuel pressure.

    a. Open manifold valve and close the idle and bypass valve.

    b. Place throttle in full fuel position.

    c. Run stand at rated speed and adjust manifold valve to total fuel flow.

    (NOTE: Pressure should agree to specification; adjust shims in throttle shaft to read 3 to 6 psi higher than specification sheet.)

    d. Test flow meter to specifications.

JOB SHEET #6

   e. Turn in rear throttle screw to trim off 3 to 6 psi and bring pump to specification.

   f. Recheck governed speed and pressure.

   (NOTE: Check throttle travel with gauge.)

12. Check point pressure.

    a. Reduce stand speed to "Check Point" speed.

    b. Check manifold pressure at check point speed; if above or below, check torque spring for seating, shimming and part number.

    c. Recalibrate pump if spring is changed.

13. Check weight assist pressure.

    a. Reduce stand speed to 800 rpm.

    (NOTE: Manifold pressure should fall within specification under "Weight Assist PSI.")

    b. Add shims in governor weight carrier to raise pressure.

    c. Remove shims to lower pressure.

    d. Recalibrate pump if shims are changed.

14. Drain and remove pump from test stand when calibration is complete.

15. Seal all openings in pump.

16. Have instructor initial here ____________ to approve the above procedures.

PT FUEL SYSTEMS
UNIT VI

JOB SHEET #7 — TIME A CUMMINS INJECTOR

A. Tools and materials

1. Basic hand tool set
2. Appropriate service manual
3. Shop towels
4. Safety glasses
5. Cummins timing tool (ST-593)
6. Breakover and socket ¾ drive to bar engine

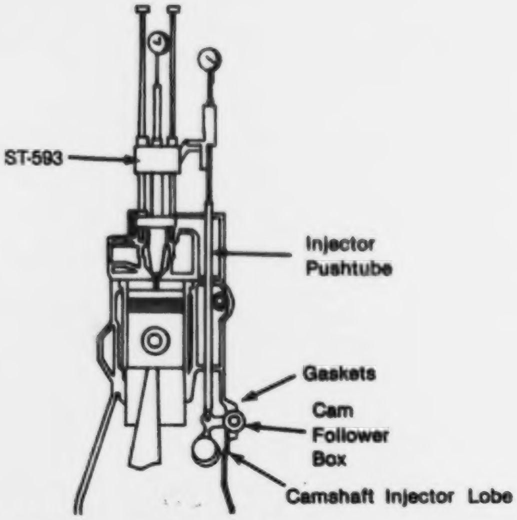
B. Procedure

(CAUTION: Follow all shop safety procedures.)

1. Bar engine over in normal direction of rotation to #1 compression stroke.
2. Bar #1 close to top dead center.
3. Install timing tool on engine. (Figure 1)

   (NOTE: Loosen set screws on dial gauge, and slide up to the top of the rod to prevent damage to gauges.)

FIGURE 1


ST-593
Injector Pushtube
Gaskets
Cam Follower Box
Camshaft Injector Lobe

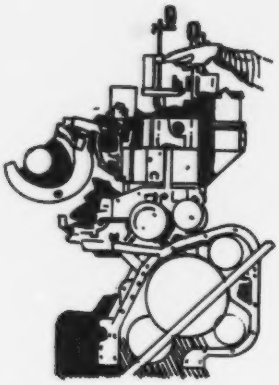
Courtesy of Cummins Engine Co., Inc.

JOB SHEET #7

4. Bar engine back and forth until piston plunger rod reaches its uppermost travel position.

   (NOTE: Hold finger on top of piston plunger rod to determine top dead center. See Figure 2.)

   FIGURE 2

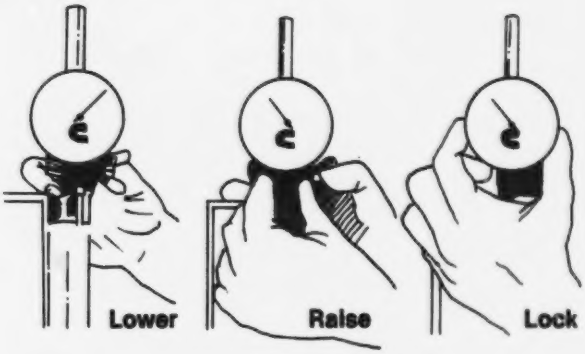


5. Slide dial down against plunger.

6. Bottom the plunger to raise the indicator .025" to .030".

   (NOTE: This prevents indicator damage. See Figure 3.)

   FIGURE 3



7. Bar engine back and forth to locate top dead center.
   a. Notice dial gauge handle over the piston will move clockwise as the piston comes up.
   b. Stop rotation of engine at exactly top dead center.
   c. Zero the dial immediately.

JOB SHEET #7

8. Rotate the engine in the direction of rotation until the piston plunger rod drops down to the 90° mark on the timing tool.

9. Center, and lower dial gauge to injector push tube.

10. Bottom the gauge, then raise back up .025" to .030".

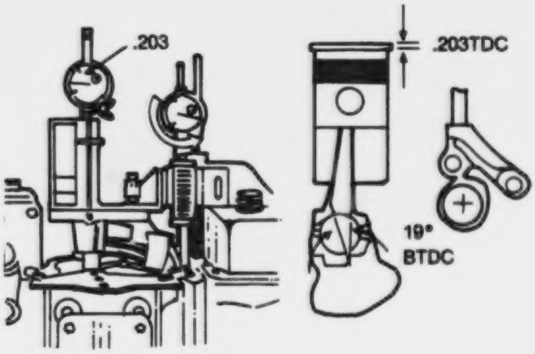
11. Zero the gauge immediately. (Figure 3)

12. Bar the engine in the opposite direction (counterclockwise) past TDC until piston plunger drops down to 45° past TDC position.

13. Rotate engine in direction of rotation to .203 before TDC.

    (NOTE: Two hundred and three thousandths inch (.203") is equal to 19° before TDC. See Figure 4.)

    FIGURE 4



(CAUTION: If you go past .203, bar in opposite direction 1/4 turn; then repeat Step 13. This keeps the backlash in the gears from affecting timing.)

14. Read the push rod indicator.

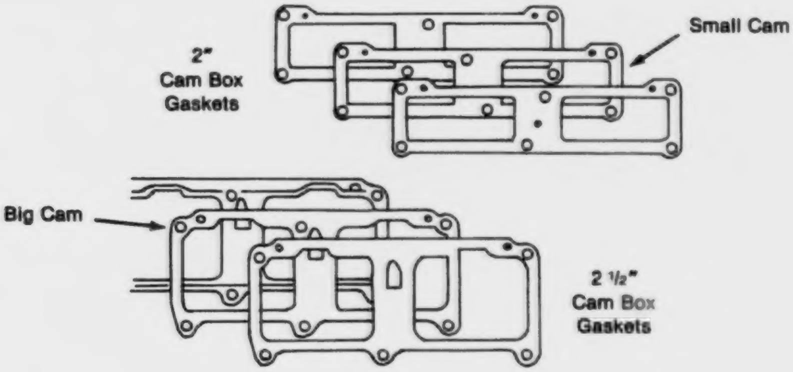
    (NOTE: This amount of travel represents the injection timing value.)

JOB SHEET #7

15. Reset timing.

(NOTE: Reset timing on 855 engine with gaskets. See Figure 5.)

FIGURE 5


2"
Cam Box
Gaskets
Small Cam
Big Cam
2 1/2"
Cam Box
Gaskets

Courtesy of Cummins Engine Co., Inc.

PT FUEL SYSTEMS
UNIT VI

PRACTICAL TEST
JOB SHEET #1 — LOCATE A FAULTY CUMMINS INJECTOR

STUDENT'S NAME ______________________ DATE __________

EVALUATOR'S NAME ______________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Started and warmed engine.	______	______
3. Shut off engine.	______	______
4. Removed valve covers.	______	______
5. Started engine.	______	______
6. Located faulty injector.	______	______
7. Checked in/put away tools and materials.	______	______
8. Cleaned the work area.	______	______
9. Used proper tools correctly.	______	______
10. Performed steps in a timely manner (____hrs. ____min. ____sec.)	______	______
11. Practiced safety rules throughout procedure.	______	______
12. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #1 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

	4	3	2	1
Located faulty injector				

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

PT FUEL SYSTEMS
UNIT VI

PRACTICAL TEST
JOB SHEET #2 — REMOVE AND INSTALL PT INJECTORS

STUDENT'S NAME ____________________ DATE __________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:		YES	NO
1.	Checked out proper tools and materials.	______	______
2.	Removed injector.	______	______
3.	Placed in rack for protection.	______	______
4.	Numbered injectors.	______	______
5.	Cleaned sleeve.	______	______
6.	Lubricated O-ring.	______	______
7.	Installed injector properly.	______	______
8.	Placed injector spring properly.	______	______
9.	Torqued injectors properly.	______	______
10.	Checked plunger for freeness.	______	______
11.	Checked in/put away tools and materials.	______	______
12.	Cleaned the work area.	______	______
13.	Used proper tools correctly.	______	______
14.	Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
15.	Practiced safety rules throughout procedure.	______	______
16.	Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #2 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

	4	3	2	1
No leaks in injector				

EVALUATOR'S COMMENTS: ____

____

PERFORMANCE EVALUATION KEY
4 — Skilled — Can perform job with no additional training. 3 — Moderately skilled — Has performed job during training program; limited additional training may be required. 2 — Limited skill — Has performed job during training program; additional training is required to develop skill. 1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

PT FUEL SYSTEMS
UNIT VI

PRACTICAL TEST
JOB SHEET #3 — ADJUST AN INJECTOR PLUNGER AND VALVES USING THE TORQUE METHOD

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ____________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Started on number one compression stroke.	______	______
3. Adjusted injector plunger, crosshead, and valves.	______	______
4. Torqued injector to specifications.	______	______
5. Torqued locknut to specifications.	______	______
6. Checked in/put away tools and materials.	______	______
7. Cleaned the work area.	______	______
8. Used proper tools correctly.	______	______
9. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
10. Practiced safety rules throughout procedure.	______	______
11. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #3 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

	4	3	2	1
Engine ran smoothly				

EVALUATOR'S COMMENTS: ____________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

PT FUEL SYSTEMS
UNIT VI

PRACTICAL TEST
JOB SHEET #4 — ADJUST AN INJECTOR USING THE DIAL INDICATOR METHOD

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ______________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:		YES	NO
1.	Checked out proper tools and materials.	______	______
2.	Barred engine to "A" or 1-6 "VS."	______	______
3.	Set rockers for #5 injector for #3.	______	______
4.	Actuated plunger to remove oil.	______	______
5.	Set up dial indicator properly.	______	______
6.	Adjusted injector and valves properly.	______	______
7.	Checked in/put away tools and materials.	______	______
8.	Cleaned the work area.	______	______
9.	Used proper tools correctly.	______	______
10.	Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
11.	Practiced safety rules throughout procedure.	______	______
12.	Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #4 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:				
Adjustments are correct	4	3	2	1
Engine runs smoothly	4	3	2	1

EVALUATOR'S COMMENTS: ____

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

PT FUEL SYSTEMS
UNIT VI

PRACTICAL TEST
JOB SHEET #5 — INSTALL A PTG FUEL PUMP, AND ADJUST HIGH AND LOW ENGINE IDLE

STUDENT'S NAME ________________________________ DATE ____________

EVALUATOR'S NAME ______________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Installed pump properly.	______	______
3. Hooked up lines properly.	______	______
4. Connected electric shut off.	______	______
5. Set the manual valve in the "off" position.	______	______
6. Set idle speed.	______	______
7. Checked rated speed.	______	______
8. Checked maximum no-load speed.	______	______
9. Checked in/put away tools and materials.	______	______
10. Cleaned the work area.	______	______
11. Used proper tools correctly.	______	______
12. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
13. Practiced safety rules throughout procedure.	______	______
14. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #5 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

Pump is properly installed	4	3	2	1
Idle and high speed are correctly set	4	3	2	1

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

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PT FUEL SYSTEMS
UNIT VI

PRACTICAL TEST
JOB SHEET #6 — TEST AND ADJUST A PTG FUEL PUMP

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ______________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Cleaned pump.	______	______
3. Drained fuel from pump.	______	______
4. Mounted pump.	______	______
5. Opened shutdown valves.	______	______
6. Closed idle valve and shutdown valve.	______	______
7. Ran pump for 5 minutes.	______	______
8. Performed suction test.	______	______
9. Adjusted pump to 8" vacuum.	______	______
10. Performed the flow test.	______	______
11. Performed the governor cut-off test.	______	______
12. Performed the throttle linkage test.	______	______
13. Performed idle fuel pressure test.	______	______
14. Performed manifold fuel pressure test.	______	______
15. Checked weight assist pressure.	______	______
16. Drained pump after removal.	______	______
17. Sealed all openings.	______	______
18. Checked in/put away tools and materials.	______	______
19. Cleaned the work area.	______	______
20. Used proper tools correctly.	______	______
21. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
22. Practiced safety rules throughout procedure.	______	______
23. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #6 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:	4	3	2	1
Pump is adjusted correctly				

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

- 4 — Skilled — Can perform job with no additional training.
- 3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
- 2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
- 1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

PT FUEL SYSTEMS
UNIT VI

PRACTICAL TEST
JOB SHEET #7 — TIME A CUMMINS INJECTOR

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ____________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Started on #1 compression.	______	______
3. Installed timing tool correctly.	______	______
4. Found TDC.	______	______
5. Set dial correctly on piston plunger.	______	______
6. Barred engine back to 90° before TDC.	______	______
7. Set push tube dial properly.	______	______
8. Stopped at .203" before TDC.	______	______
9. Determined timing.	______	______
10. Corrected timing.	______	______
11. Checked in/put away tools and materials.	______	______
12. Cleaned the work area.	______	______
13. Used proper tools correctly.	______	______
14. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
15. Practiced safety rules throughout procedure.	______	______
16. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #7 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:				
	4	3	2	1
Injector is timed correctly				

EVALUATOR'S COMMENTS: ______________________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

PT FUEL SYSTEMS
UNIT VI

NAME ______________________________ SCORE ________________________

TEST

1. Match the terms on the right with the correct definitions.

_____a. Pressure time system based on principle that volume of liquid flow is proportionate to fluid pressure, time allowed to flow, and size of the passage through which liquid flows

_____b. PT fuel pump which is governor controlled

_____c. PT fuel pump which is pressure regulated

_____d. Cummins injector based on the pressure time system

_____e. Engine rpm's under full load

_____f. To supply in a measured amount

_____g. Engine rpm's with no-load and throttle fully open

_____h. PT pump with air fuel ratio control

1. High idle or maximum no-load speed
2. Meter
3. PTG AFC
4. PT injector
5. PT system
6. PT type G
7. PT type R
8. Rated speed

2. Name the three main parts of a PT fuel system.

a. ____

b. ____

c. ____

3. Match the main units of a PT pump assembly on the right with the functions.

_____a. Draws fuel from supply tank forcing it through the pump filter screen into the pressure regulator valve

_____b. Limits pressure of fuel to the injectors

_____c. Provides manual control of fuel flow to injector under all conditions in operating range

_____d. Controls flow of fuel from idle to maximum governor speed

1. Gear pump
2. Governor assembly
3. Pressure regulator
4. Throttle

TEST

4. Select true statements concerning the operation of a PT injection system by placing an "X" beside each statement that is true.

    _____a. Gear type fuel pump delivers fuel through a restricting throttle to the governor.

    _____b. From the fuel pump, the fuel goes to a manifold which feeds cam-operated injectors in the cylinder head.

    _____c. Injector raises pressure to produce a good spray and times the start of injection.

5. State the function of a pulsation damper.

    ____

    ____

6. Complete the following list of statements concerning the operation of a mechanical governor.

    a. Between idle and maximum speed, fuel flows through the governor to the injector in accordance with engine requirements as controlled by the __________.

    b. When engine reaches governed speed, the governor weights move the governor plungers so fuel passage to the injectors is ______________________.

    c. Fuel leaving the governor flows through the shut down valve, inlet supply lines, and onto the ______________________________________.

7. Name two types of PT injectors.

    a. ____

    b. ____

8. Match the operational steps of PT injectors on the right with the descriptions.

    _____a. 1) Fuel enters the injector at fuel inlet

    2) Balance orifice controls quantity of fuel that enters the injector cup

    _____b. 1) Downward plunger movement cuts off fuel entry into injector cup

    2) Continued downward movement forces fuel from injector cup through the spray orifice into combustion chamber

    1. Air fuel ratio control
    2. Cooling
    3. Injection
    4. Metering

TEST

_____c. While plunger is down, fuel passes through upper hole around undercut in plunger through return passages to the fuel tank

_____d. 1) Made to replace the PTG pump and aneroid on turbocharged engines

2) Limits fuel pressure and flow restriction

3) Gives the correct air fuel delivery rate to the engine during acceleration

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

9. Demonstrate the ability to:
   - a. Locate a faulty Cummins injector. (Job Sheet #1)
   - b. Remove and install PT (type B, C, D, and PTD Top Stop) injectors. (Job Sheet #2)
   - c. Adjust an injector plunger and valves using the torque method. (Job Sheet #3)
   - d. Adjust an injector using the dial indicator method. (Job Sheet #4)
   - e. Install a PTG fuel pump, and adjust high and low engine idle. (Job Sheet #5)
   - f. Test and adjust a PTG fuel pump. (Job Sheet #6)
   - g. Time a Cummins injector. (Job Sheet #7)

PT FUEL SYSTEMS
UNIT VI

ANSWERS TO TEST

1. a. 5
b. 6
c. 7
d. 4
e. 8
f. 2
g. 1
h. 3

2. a. Fuel pump
b. Supply lines, drain lines, and passages
c. Injectors

3. a. 1
b. 3
c. 4
d. 2

4. a, c

5. The damper contains a steel diaphragm which absorbs pulsations and smooths fuel flow through system

6. a. Throttle
b. Reduced
c. Injectors

7. a. PTD Top Stop
b. PTB, C, D

8. a. 4
b. 3
c. 2
d. 1

9. Performance skills evaluated to the satisfaction of the instructor